POWER PLANT ENGINEERING

Established Over 29 Years

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When the Pipe Stretches Its Muscles

YOU HAVE often seen a man, preparing to begin some kind of manual work—such as digging, or wielding a heavy sledge or lifting a weight—take a few seconds before beginning the job to spit on his hands, get a good firm foundation for his feet and finally flex his muscles a few times. Then, when he performs the work, his muscles stretch to the limit, depending on their elasticity, and the amount of work they have to do.

Similarly, when we want a pipe to do work for us, we must allow it to stretch its "muscles". So we provide it with expansion joints, similar to the one shown above. This is a 16-in. double joint, made of steel, to carry steam at pressures up to 250 lb. per sq. in. and total temperatures of 650 deg. An article on page 586 of this issue discusses in an interesting way the latest practice in applying of expansion joints to steam lines.

Philo Station Establishes Record of Economy

BASE LOAD STATION EQUIPPED WITH TWO 40,000 KW. UNITS AND SO LAID OUT THAT FOUR MORE UNITS OF THE SAME SIZE MAY BE ADDED TO IT

COMPLETION OF THE new power station at Philo, O., adds another link to the great system of 1,250,000 kw. generating capacity which is under control of the American Gas & Electric Co. Specifically, this station is operated as a base load plant by the Ohio Power Co. and as such it is interconnected with a vast distribution system which is roughly bounded by Wheeling, W. Va., South Bend, Ind., Toledo and Cleveland, O., and Pittsburgh, Pa.

Economy to be expected from a station is primarily based upon the design. The use at Philo of high steam pressure, reheating the steam, stage extraction, and many other features of design assured a high economy. Thus by operating this station on a base load it is possible to derive from it an economy of operation far beyond that which is usually obtained. This is fully evidenced by a survey of the operating report for April, 1925. During that period a plant thermal efficiency of 23.81 per cent was realized and the B.t.u. per kilowatt-hour output, measured on the outgoing side of the step-up distribution transformers, was 14,343. Other figures disclosed by this remarkable performance were: that, 1.34 lb. of coal was used per kilowatt-hour output, the coal averaging 10,390 B.t.u. as fired and containing 10.38 per cent moisture and 14.85 per cent ash. The B.t.u. lost in the ash was 136 per lb. The average boiler rating was about 221 per cent.

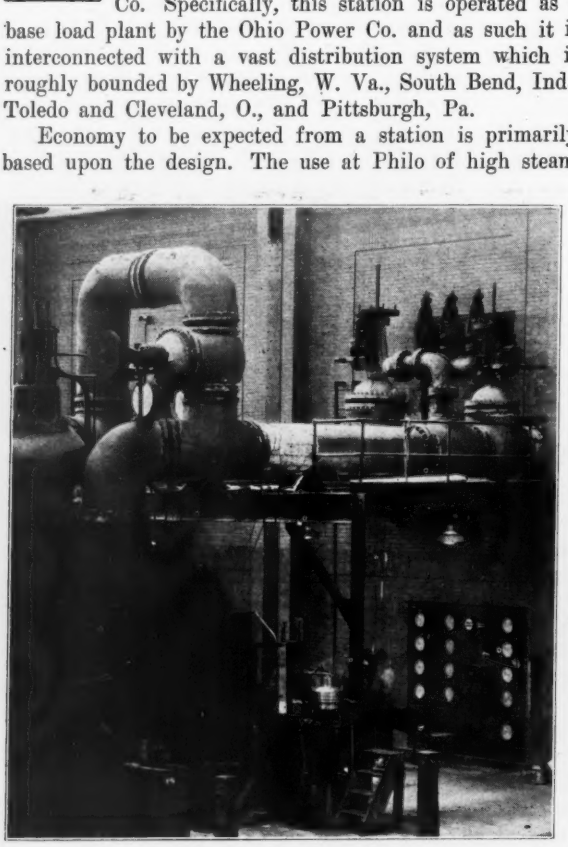


FIG. 1. STEAM IS REHEATED AFTER THE SEVENTH STAGE. NOTE OIL PURIFIER AND GAGE BOARD

During the month of March one generating unit was out of service most of the time and the resultant capacity factor was 33.9 per cent.

Economy derived from this station can be attributed to two factors, one being the design of the station and the other the character of the load. Philo station is essentially a manufacturing plant. It was designed to produce a marketable commodity at the lowest possible price. It is concerned only with production and delivery of the product, electrical energy to the outgoing side of the step-up transformers. At that point it is picked up by the purchaser or distributor. Philo has its own repair shops, accounting, stores and purchasing departments, and it carries its own pay roll. It is thus a complete manufacturing plant, producing and delivering for market a finished product derived from raw materials.

Two units of 40,000 kw. at 95 per cent power factor are now in operation and arrangements have been made whereby four additional units may be installed at a later date. An interesting feature of this future planning lies in the fact that the temporary wall is inclosed with reinforced concrete slabs which are secured to the temporary end columns by means of clip bolts. The advantage of this

OPERATING RESULTS AT PHILO STATION

Week Ending -	April 11	April 18
Plant thermal efficiency	23.86	24.90
B.t.u. per kw.hr. output	14315	13715
Lb. coal per kw.hr. generated	1.25	1.25
Lb. coal per kw.hr. output	1.32	1.32
Total kw.hr. generated	5,581,000	5,312,000
Total kw.hr. output	5,276,000	5,020,130
Total kw.hr. auxiliary power	223,600	217,230
Per cent auxiliary power	4.01	4.09
Total coal consumed - lb.	6,962,000	6,624,000
Total water to boilers - lb.	50,525,000	49,559,000
Total treated water used - lb.	1,741,000	1,641,080
Aver. plant water rate per kw.hr. output	9.58	9.87
Aver. plant water rate per kw.hr. generated	8.05	8.26
Aver. condenser pres., in. ab.	0.84	0.92
Aver. temp. circulating water, inlet	51	57
Aver. temp. circulating water, outlet	58	65
B.t.u. per lb. coal as fired	10,845	10,390
Per cent moisture in coal	8.49	10.38
Per cent ash in coal	14.74	16.67
Per cent combustible in ash	7.34	6.54
Per cent coal lost in ash	1.52	1.60
B.t.u. per lb. of coal lost in ash	165	166
Aver. steam pres., lb. ga.	535	534
Aver. steam temp. deg. F.	706	704
Aver. temp. feed water to economizer	189	193
Aver. temp. feed water to boilers	302	313
Aver. temp. flue gas, boiler outlet	569	591
Aver. temp. flue gas, stack, unit #1	353	361
Aver. temp. flue gas, stack, unit #2	-	254
Aver. temp. flue gas, economizer outlet	353	356
Aver. actual evap. per lb. coal	7.26	7.48
Aver. evap. from and at 212 deg. F.	8.97	9.20
Aver. factor of evap.	1.235	1.230
Aver. per cent boiler rating	231.65	221.42
Aver. per cent eff. boiler, furnace & economizer	80.26	85.93
Aver. plant load factor	89.78	81.07
Aver. generated load per turbine service hr.	33220	29186

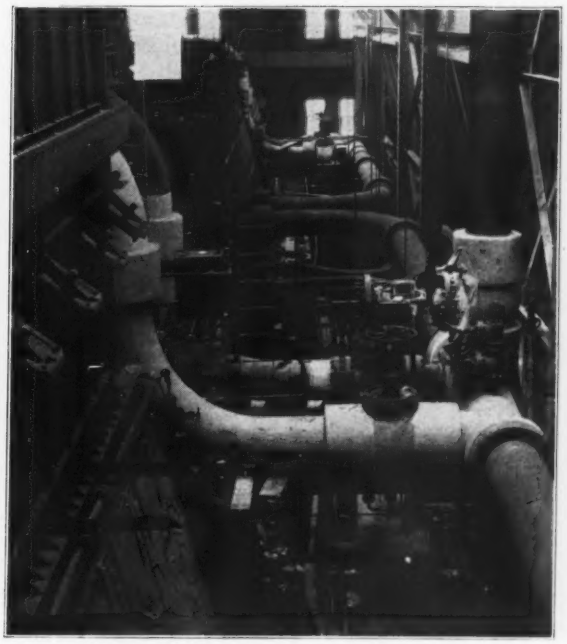


FIG. 3. EXPANSION OF THE BOILER ROOM STEAM PIPE IS TAKEN UP WITHIN THAT ROOM

construction is that when connections are to be made for an extension it is necessary to remove only those slabs which are opposite the field connections. Later the temporary columns, end framing and the slabs can be moved and set up in their new location.

Some Equipment Installed for Ultimate Capacity

Cost of installing the first two units is of necessity higher than it will be for those to be installed later. This is explained in that, although only one-third of the generating capacity is in, the total cost for other items has been fully covered. The full capacity of this station can now be installed without additional cost for land, coal storage and handling facilities, yard trackage, repair shops, water supply and stores and office space.

Building space proportions in cu. ft. per kw. of rated capacity are as follows: boiler room, 39.4; turbine room, 16.6; switch house, 2.6; crib house, 4.9 and miscellaneous, 28.3. 21.2 cu. ft. per kw. of this volume is available for the use of future installations, making a net total of 70.6 cu. ft. per kw.

Current is generated at 11,000 v., the generator leads extending to the step-up transformers, which are located just outside of the building. There the voltage is raised to 132,000 v. and the current carried across the yard to the high tension switch yard from which there are at present three outgoing lines. Construction is now under way for a fourth outgoing line. It is of interest to note that there is no high tension bus system within the building. The 11,000-v. generator leads are tapped for house service ahead of the main circuit breaker. This house service is obtained by means of three 11,000/2300-v. transformers. Thus the switch house equipment was designed for 2300 v. only.

Philo station is located about 9 mi. down the Muskingum River from Zanesville, O. At that point the river makes a slight bend. At the north end of this bend the government had constructed a dam as an aid to navigation. A canal had been dredged across the flat formed by the bend and a lock, suitable for river navigation, had been built at the downstream end of the canal.

Several years ago, during a period of high water, the flat was flooded, the result being that a portion of the old

FIG. 2. DECK PLATE GIRDER SPANS SUPPORT THE TRACK FROM WHICH COAL IS DUMPED INTO THE SUBMERGED STORAGE SPACE

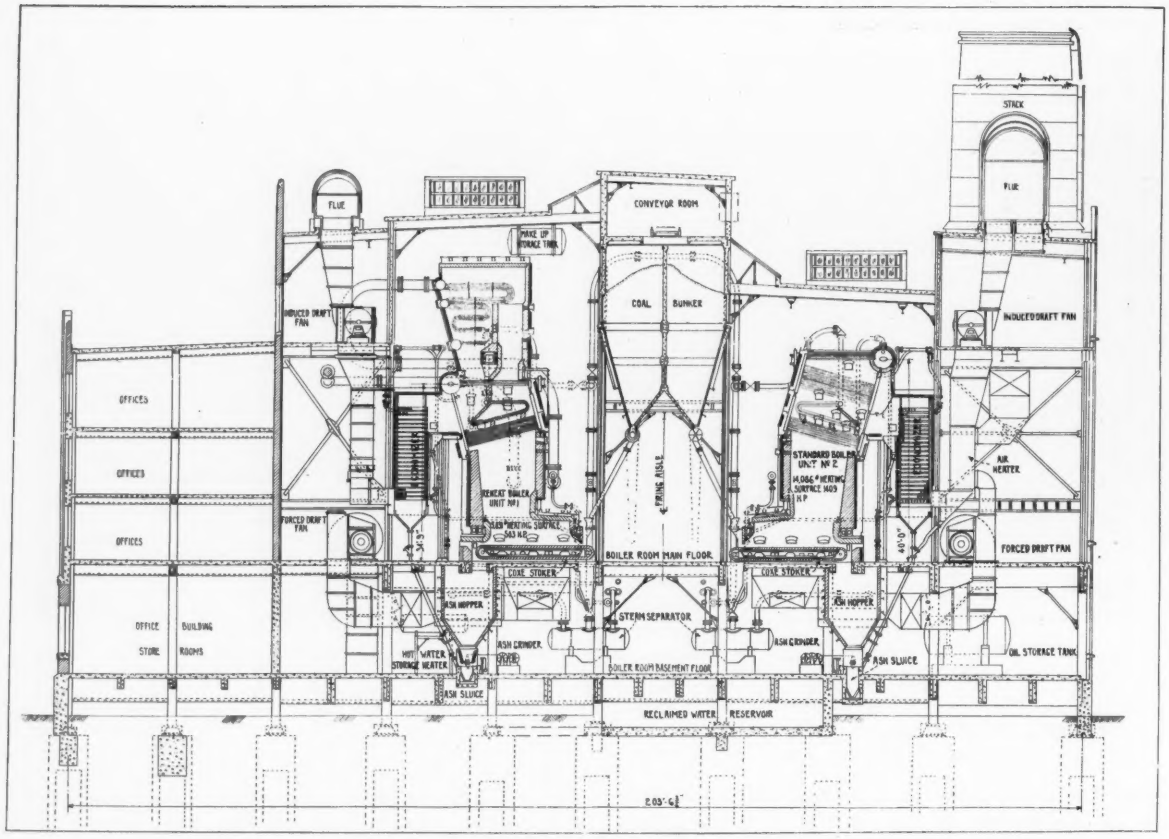


FIG. 4. LOWER SECTION OF THE REHEAT BOILERS GENERATE STEAM IN PARALLEL WITH THE STANDARD BOILERS

canal was swept away and the river cut a new outlet for the canal. It so happened that this new outlet was north of the old lock, thus making the lock useless without the expenditure of a comparatively large sum of money to get the canal back in its old channel. Had this been done there would still have remained the danger of high water again destroying the canal.

Surveys of the situation led the government to abandon the use of the entire canal and to construct a new lock at the west end of the dam, thus restoring the river to navigation at that point and leaving an ideal site for the location of a central station. The dam is at the upper or north end of the property, serving as it does the purpose both of a deflecting dam and to insure a head of water at least equal to that of its crest.

Part of Old Canal Used for Coal Storage

Advantage could be taken readily of the old canal for two purposes, one for delivery of water to the plant from above the dam and also to serve as a coal storage pit for that portion of the coal which it would be desirable to store under water.

These natural advantages have all been taken advantage of at Philo Station. The plot of ground through which the old canal ran comprises a total acreage of 114.75 and is crescent shaped, the canal following closely the inner radius of the crescent. Thus at the widest part of the crescent was found ample space to locate the power plant and the high tension switch yard.

Immediately above the dam and at the upstream opening of the canal a baffle wall has been constructed. Directly opposite the dam and in the main channel of the canal were placed two gates, each 7 ft. wide by 8 ft. high. These gates were removed when the plant was ready to operate. Thus the water required for condensing purposes flows from above the dam, through the upper portion of the canal to the intake crib house. The canal has been left open to a point just south of where the third crib house will be located to take care of future units. It is closed off at that point by an earth embankment through which

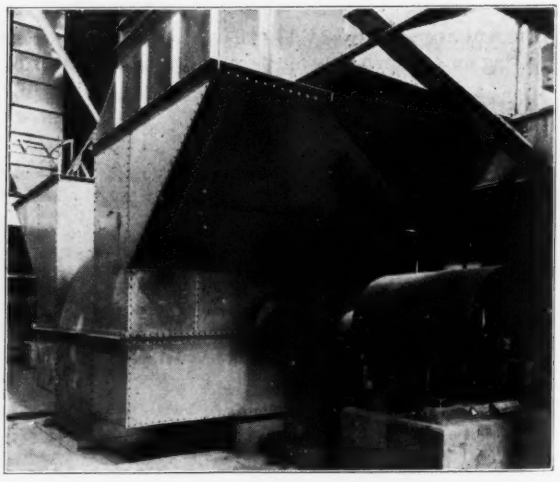


FIG. 5. FORCED BLAST FANS ARE EACH DRIVEN BY TWO MOTORS OF DIFFERENT RATINGS

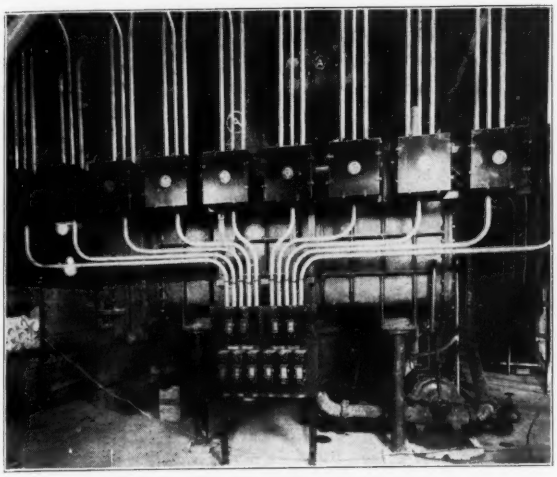


FIG. 6. THIS IS AN EXCELLENT EXAMPLE OF HOW ELECTRIC CONTROL EQUIPMENT SHOULD BE INSTALLED

a head gate connection is made so that the lower end of the canal, which forms the coal storage pit, can be flooded to practically the height of the water level over the dam crest.

The distance from the center line of the present crib house to this cut-off dam in the canal is about 470 ft. From that point south for a distance of 1176 ft. the canal has been made wider and deeper to serve as a submerged storage space for coal. The coal storage capacity thus derived from the canal is about 300,000 T.

Just north of the crib house and forming part of the main structure is the water treating plant. The basement of the boiler room, the firing aisle of which extends east and west, adjoins the treating plant and extends to the turbine room which, with the switch house, forms the east end of the plant. The step-up transformers have been placed east of the building and the high-tension switch yard is at the east property line which is the river bank.

North of the building are the storage tanks, one being used for the storage of turbine oil and the other two, located overhead, are for the storage of distilled water for boiler make-up use and for ground water storage. Ground water is obtained from two wells located near the river bank.

Several interesting phases of operation result from the use of the available head resulting from the fall of the river at this point, the river dam at the upper end of the property and the corresponding elevation of the canal bottom. The elevation of the crest of the dam is 672.9 ft. The high water elevation is 706.64 ft. and the lower pool elevation is 661.62 ft. The basement floor is at elevation 708 ft. or about 1.36 ft. above extreme high water. The bottom of the screen pit is 59 ft. below the basement floor. The floor of the condenser well, which is 70 ft. in diameter, is 65 ft. below the basement floor and 29.9 ft. below the dam crest.

Vertical Type Condensers Were Installed

Condensers are of the vertical, two-pass type and they are so located in the well at such a height as to permit water circulation on the syphon principle, the circulating system being so proportioned that as long as the head of water over the dam crest is 7 ft. or more it is not necessary to use circulating pumps. This condition holds true for about 10 mos. out of the year, so although circulating pumps have been provided they are used only for standby service. Thus one of the big auxiliary power charges is not carried for the greater portion of the year.

Circulating water leaving the canal enters the intake crib, passes through a bar-iron grill and then through the

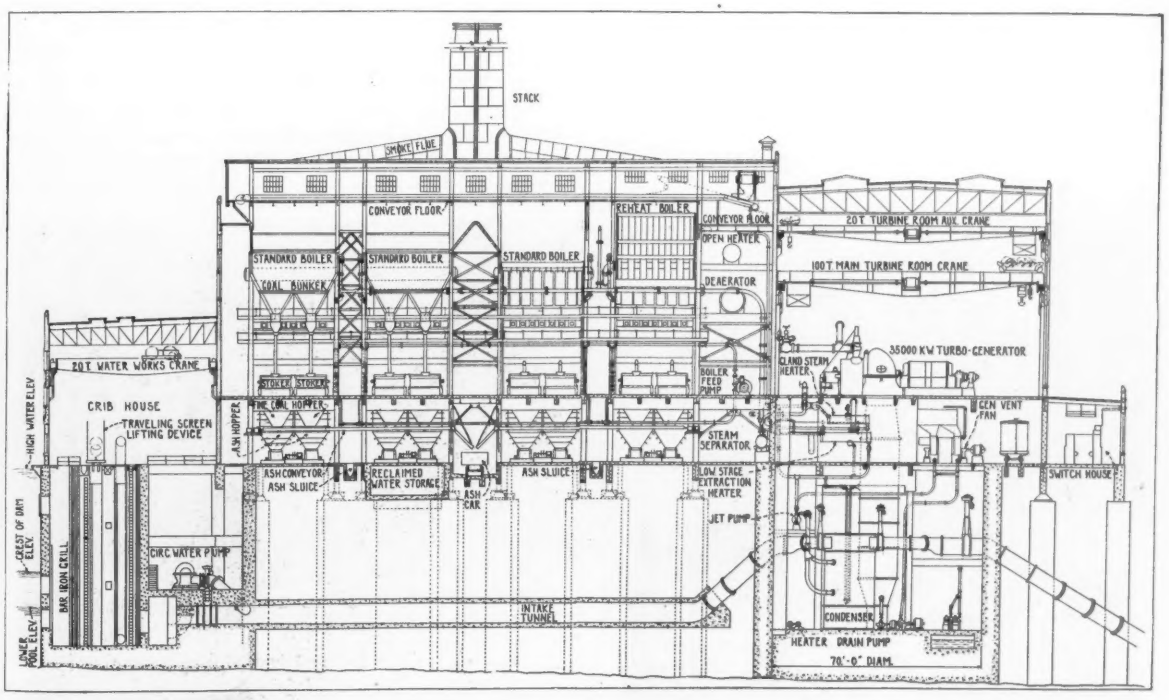


FIG. 7. CIRCULATING WATER ENTERS AT THE CRIB HOUSE AND FLOWS BENEATH THE BOILER ROOM TO THE VERTICAL CONDENSERS

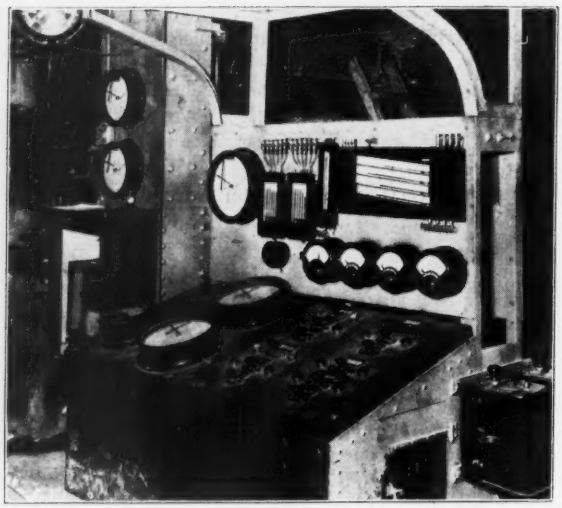


FIG. 8. THIS IS THE CONTROL BENCH FOR ONE BOILER. ONE FIREMAN HAS CHARGE OF TWO BENCHES

traveling screens, of which there are five. The water then either enters the intake tunnel or it may be bypassed through the circulating pumps which are located in the crib house. The intake tunnel extends under the boiler room and is connected to each condenser at the top of the first pass. The path of the water is upward in the second pass and therefore leaves the condenser from the top water compartment. Condensers are also connected up so water circulation can be reversed for cleaning. This feature has enabled long operation without shutdown for condenser cleaning.

Foreign matter will of course collect in the lower water compartments of the condensers. Therefore, a motor driven pump has been installed at each condenser so that this accumulation may be pumped out. It has been found that during normal flow of the river these pumps need be used but a short time during each week. During rainy and flood seasons it will be necessary to pump out every hour or two.

Several interesting features center around the condenser well. In the first place, it was constructed in circular sections. As each section was finished, the supporting soil was dredged out, thus allowing the great cylinder to settle down until it finally rested on bed rock and a floor 16 ft. thick was poured under water. After this set up, the well was pumped dry and a finishing floor installed. The two turbo-generators are so placed that their weight is carried directly on the well. An electric elevator travels between the turbine room operating floor and the bottom of the well.

The operating room is above the switch house and at the south-east corner of the building. It is so constructed that it receives daylight from three sides, the fourth side being separated from the turbine room by a glass partition. Thus the operators have a full view of the turbine room and the high tension yard. A rather ingenious arrangement of indicator gages has been installed in the wall between the turbine and boiler rooms. These gages are of the double-face, illuminated type, and therefore can be seen from the boiler room, the turbine room and the operating room. Thus all operators see the same master gages, which show the present as well as expected load, boiler feed pressure, throttle pressure and the first stage bowl pressure.

Two 40,000 kw. General Electric Co., Curtis-type, turbo-alternators occupy the center one-third of the turbine room. These machines are rated at 95 per cent power factor and generate at 11,000 v., three phase and 60 cycles. Steam pressure at the throttle is 550 lb. ga. and the total temperature is 725 deg. F. After the 7th stage the steam, which is then at 150 lb. ga. pressure and slightly superheated, is bled from the turbine and reheated in the reheat boiler. It returns to the turbine at a pressure of 147 lb. ga. and a temperature of 725 deg. and enters the 8th stage. It then passes through to the last or 18th stage and discharges into the vertical exhaust pipe which opens into the condenser.

Ejectors Used to Prime Condensers

On this exhaust line is a slip expansion joint which is packed with hemp and sealed with water from the hot well. This relieves the turbine of all strain and since clean water is used for sealing, leakage to the condenser causes no concern. These condensers were made by the Wheeler Condenser & Engineering Co. and each is rated to con-

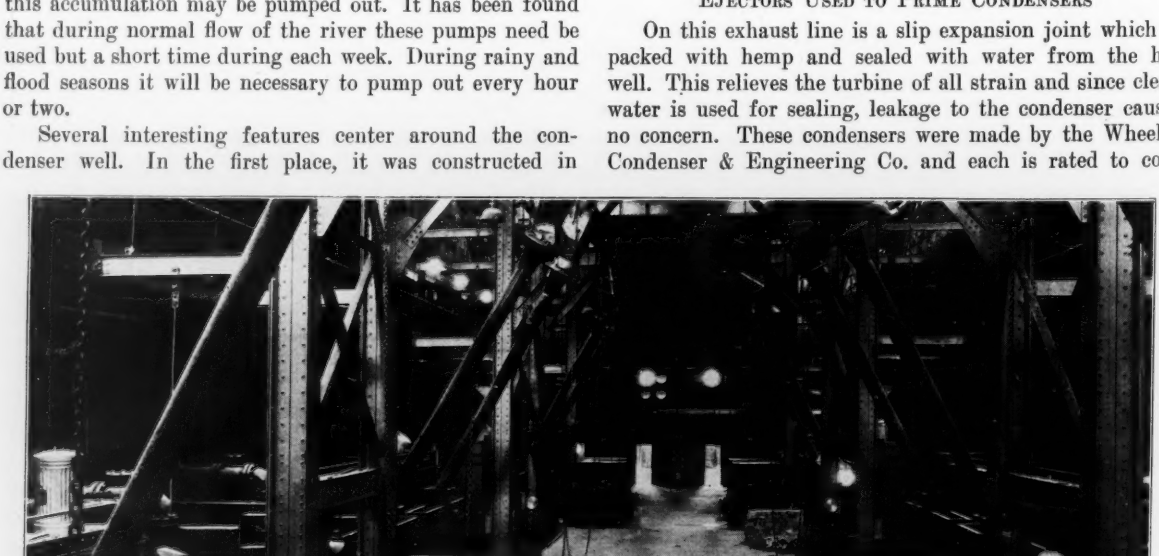


FIG. 9. BOILER PLANTS MAY BE LAID OUT WITH CENTER FIRING AISLES AND STILL MAKE GOOD USE OF DAYLIGHT

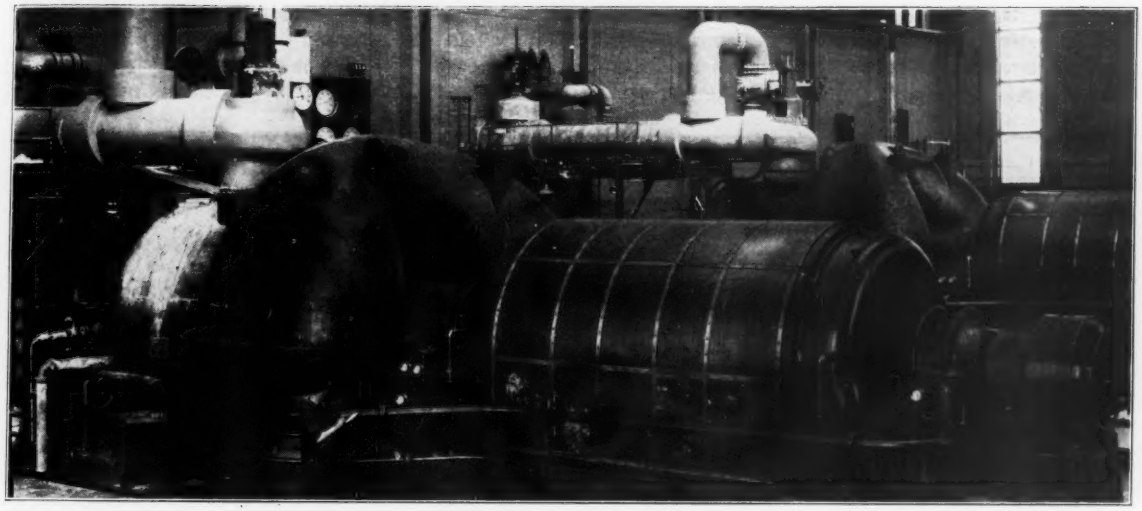


FIG. 10. TWO 40,000 KW. UNITS ARE NOW IN OPERATION. ULTIMATELY FOUR MORE SIMILAR UNITS WILL BE INSTALLED

dense 300,000 lb. of steam per hour. The vacuum pumps are of the steam jet type. Ejectors are used to prime the condensers with circulating water.

Each turbine is equipped with a centrifugal oil purifier, through which a ½-in. stream of oil passes continuously. Back of each turbine is a gage board on which are mounted in addition to a number of indicators, the following Foxboro recorders; incoming and outgoing temperature of the air to the generators, the water temperature to and from the air coolers, and the oil temperature to and from the thrust bearing. There are also recorded the steam pressure and temperature at the throttle, the steam pressure and the temperature to and from the reheater and the temperature of the exhaust steam.

In the event of a line surge, which would cut out a generator, the main throttle valve and an intercepting valve between the reheat boiler and the low pressure stages of the turbine will be automatically closed, thus cutting off the turbine from its steam supply, and at the same time air admission doors at the reheat element of the reheat boiler will be opened, thus protecting the reheater against overheating. The operation of the intercepting valve will be through relay circuits which switch the forced draft fan and the induced draft fan to their lower rated motors.

Each generator shaft is fitted with a direct-connected exciter rated at 250 kw. and 250 v. The generators are cooled by a closed system, the air in which is cooled by a fin type cooler. Two motor driven fans circulate the air during the summer months and but one is used during the cooler months. It has been found that the leakage of air on the suction side of the fans is not enough to compensate for that lost through leakage on the pressure side, therefore, a Midwest air filter has been installed in each suction duct, thus admitting the necessary make-up air.

On the turbine operating floor is a 35-kw., m.-g. set for charging a 250-v. storage battery, which is used in connection with the operation of valve motors and the switch gear, and also serves to furnish energy for emergency lighting. Also on this floor are two synchronous condensers, used for power factor correction made necessary by use of induction motor drives throughout the plant.

Another interesting feature is that the machine shop is located at the north end of the turbine room and at the basement floor level which is served by a rail connection to the yard. Here the routine repairs of plant equipment are made and the turbine room cranes are utilized to advantage in handling parts. A permanent transformer skid has been built in the shop so that when a transformer is brought from the yard on a railroad car it can be slid over to this permanent skid which stands at the same height as the floor of the car.

Two Overhead Cranes in Turbine Room

One other deviation from usual practice is that instead of there being one overhead crane with hooks of different capacity, this turbine room is equipped with two cranes operating on separate runways. A 100 T. crane travels on the lower runway and a 20 T. crane on the runway above. Both cranes are available for use on the turbines, the machine shop floor and the spare unit storage space. One advantage of having the light crane is that it is fast and it is of ample size to handle most of the work on the floors mentioned.

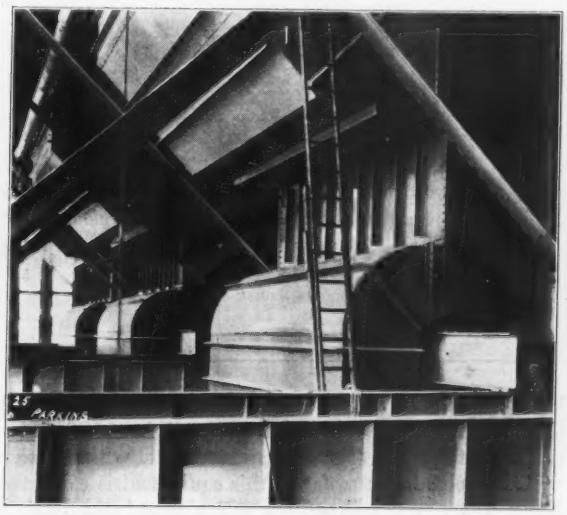


FIG. 11. AIR PREHEATERS ARE BEING INSTALLED AHEAD OF THE FORCED BLAST FANS

At the south end of the turbine room and on a level with the machine shop is a storage space provided for a spare generator. Special skids have been constructed and heating coils will be installed so that the generator can be kept dry. At the Twin Branch Station, now being built by this company near South Bend, Ind., will be stored a spare turbine rotor and a spare transformer. These two stations will be duplicates in so far as this equipment is concerned. At each station a railroad car will always be available so that should a generator burn out at Twin Branch Station the spare can be sent from Philo and if Philo needs a transformer or a turbine rotor it can be obtained on short notice from Twin Branch.

Three standard and one reheat boiler serve each turbine. These are arranged so that there are four on each side of a central firing aisle. They are so piped that the four boilers on one side of the aisle serve one turbine and the four on the opposite side serve the other turbine unit. As previously mentioned, when describing the turbine units, the steam is reheated after the seventh stage. Provision for this has been made in the boiler room by the installation of two reheat boilers, one for each turbine.

Principal Equipment at the Philo Station

Main Generating Units—
- Make....General Electric Co.
- Number....2
- Rating..40,000 kw. 95 per cent p.f., 11,000 v., 3 ph., 60 cyc.
- Steam temp....725 deg. F.
- Steam pres. at throttle....550 lb. ga.
- Exciters....direct conn., 750 kw., 250 v.

Condensing Equipment—
- Make....Wheeler Cond. & Eng. Co.
- Number....1 condenser per unit
- Type....Vertical
- Passes....2
- Surface sq. ft....45,000, provision for 52,000
- Tubes....1 in. Muntz, 18 ft.

Circulating pumps, No....2
- Type....double suction
- Capacity....35,000 g.p.m.
- Head....16 ft.
- Drive....motor, 350 hp. squirrel cage

Hot well pumps, No....2 per unit
- Type....Centrifugal
- Capacity....700 g.p.m. each
- Head....235 ft.
- Drive....125 hp. squirrel cage motor

Air pumps, No....2 per unit
- Type....Steam jet, inter and after condensers
- Capacity....48 c.f.m. at 29.5 in. vac.

Sand Pumps, No....2
- Type....Centrifugal
- Capacity....1000 g.p.m.
- Head....65 ft.
- Drive....40 hp. squirrel cage motor

Standard Boilers, make....Babcock & Wilcox Co.
- Number....6
- Type....cross drum
- Heating surface....14,068 sq. ft.
- Working pressure....600 lb.
- Superheater....B. & W., convection
- Steam temperature....725 deg. F.

Reheat Boilers, make....B. & W. special cross drum
- Number....2
- Heating surface, high pres. part....5031 sq. ft.
- Pres., high pres. part....600 lb. per sq. in.
- Steam temp., high pres. part....725 deg. F.
- Steam temp., reheat portion....725 deg. F.

Economizers, make....Babcock & Wilcox Co.
- Type....Duratex
- Number....8
- Heating surface....8837 sq. ft.

Stokers, make....Combustion Eng. Corp.
- No. per boiler....2
- Type....Coxe, forced blast
- Effective area....356 sq. ft.
- Drive....3-hp. d.c., var. speed

Forced draft fans, make....Green Fuel Econ. Co.
- Number....8
- Type....Radial flow
- Capacity..55,000 c.f.m. at 3½ in., 70,600 c.f.m. at 5 in.
- Drive...two motors, const. speed, 75 and 125 hp., a.c.

Air Heaters, make....Combustion Eng. Corp.
- Type....Plate
- Heating surface....9700 sq. ft. each

Induced draft fans, make....Buffalo Forge Co.
- Number....8
- Type....Straight blade
- Capacity..108,000 c.f.m. at 4 in., 130,000 c.f.m. at 5 in.
- Drive..Two motors, variable speed, 125 and 250 hp., a.c.

Stacks, type....Steel
- Height above boiler room floor....155 ft.
- Number....2
- Diameters....One, 16 ft., one 22 ft. 6 in.

Air compressor, make..Worthington Pump & Mach. Corp.
- Capacity....670 c.f.m.
- Pressure....100 lb. per sq. in. ga.
- Drive....125 hp. syn. motor

Generator air coolers, make....General Elec. Co.
- Number....12
- Type....Surface
- Water supply, 6 units....Condensate
- Water supply, 6 units....Ground water

Generator ventilating fans, make..Green Fuel Econ. Co.
- Number....2 per unit
- Type....Steel plate
- Capacity, each....45,000 c.f.m.
- Pressure....10 in. water
- Drive....150 hp. squirrel cage motor
- Air filters....Midwest Air Filters, Inc.

Turbine oil purification, make....DeLaval Steam Turbine Co.
- Type....Centrifugal
- Capacity....200 gal. per hr.
- Number....One per unit

Heaters, make....Elliot Co.

Low stage extraction, type....Closed
- Number....One per unit
- Steam pres....6 lb. absolute
- Capacity, water....300,000 lb. per hr.
- Passes....3
- Heating surface....1770 sq. ft.

Feed water, type....Open
- Number....One per unit
- Steam pres....3 lb. ga.
- Capacity....300,000 lb. per hr.

Gland steam condensers, make....Elliott Co.
- Number....One per unit
- Type....Surface
- Steam pres....Atmospheric
- Capacity, water....250,000 lb. per hr.
- No. passes....3
- Heating surface....1050 sq. ft.

Deaerators, make....Elliott Co.
- Number....One per unit
- Capacity....300,000 lb. per hr.
- Air removal....Steam jet pumps

Evaporator, make....Wheeler Cond. & Eng. Co.
- Number....1
- Type....Quad. effect, film, reversing
- Capacity....40,000 lb. per hr.
- Evaporator condenser, type....Surface
- No. passes....2
- Surface....2250 sq. ft.

The standard boilers are of the Babcock & Wilcox cross-drum type. Each contains 14,086 sq. ft. of heating surface and is designed for a steam pressure of 650 lb. ga. The maximum steam generating rate of each boiler is 150,000 lb. per hr. The inter-deck, connection type superheater, containing 2485 sq. ft. of surface, to give a total steam temperature of 750 deg. F., is placed between the eighth and ninth rows of tubes. The front header is 25 ft. 8⅛ in. above the operating floor, which provides a combustion space of 5430 cu. ft.

Each boiler is fired by two Coxe forced-blast stokers which are driven at the rear by variable speed d.-c. motors through one spur-gear and two worm-gear speed reducers. These stoker motors are the only d.-c. motors in the plant and therefore two m.-g. sets have been installed in the boiler room to serve these motors. The grate surface of each individual stoker is 356 sq. ft.

Five feet above the grate is a Detrich arch which is 10 ft. long. At the rear end of the stoker is a short arch so that the throat of the furnace is 7 ft. 9 in. deep. The distance from the grate to the first row of tubes is about 20 ft. Gases leaving the combustion chamber enter for the

Principal Equipment at the Philo Station

Boiler feed pumps
..2 Weir type by Bethlehem Shipbuilding Corp., 750 g.p.m., 650 lb., g.a., turbine drive. 2-Cameron, 6 stage, 750 g.p.m. 650 lb., 600 hp., squirrel cage motor drive.

Miscellaneous Pumps—

Heater drain, make..Worthington Pump & Mach. Corp.
Capacity ..... 80 g.p.m.
Head ..... 250 ft.
Drive ..... 20 hp. squirrel cage motor
Number 3

Make-up pumps, make..... Yeomans Bro. Co.
Number 2
Capacity ..... 100 g.p.m.
Head ..... 110 ft.
Drive..... 15 hp. squirrel cage motors

Treated water pumps, make.....
.....Worthington Pump & Mach. Corp.
Number 2
Capacity ..... 200 g.p.m.
Head ..... 150 ft.
Drive ..... 20 hp. squirrel cage motors

Service pumps, make..Worthington Pump & Mach Corp.
Type ..... 2 stage
Number 3
Capacity, each ..... 1500 g.p.m.
Head ..... 220 ft.
Drive ..... 150-hp. squirrel cage motors

Ground water reclaiming pumps, make.....
.....Worthington Pump & Mach. Corp.
Type ..... Single stage
Number 2
Capacity, each..... 500 g.p.m.
Head ..... 75 ft.
Drive ..... 20-hp. squirrel cage motors

Ground water supply pumps, make..American Well Wks.
Type..... 6 stage, deep well
Number 2
Capacity, each..... 750 g.p.m.
Head ..... 250 ft.
Drive..... 100-hp. squirrel cage motors

Traveling screens, make..... Chain Belt Co.
Number 5
Size..... 7 ft. by 64 ft. 2 in.
Speed..... 9 ft. per min.
Screen openings..... ⅜ in. square
Driven by..... Two-speed, squirrel-cage, motors

Cranes, make ..... The Morgan Eng. Co.
Use ..... Screen handling
Span ..... 54 ft. 7 in.
Capacity ..... 20 T.

Use ..... Turbine room
Span ..... 87 ft. 6 in.
Capacities..... 100 T. and 10 T. hooks

Use ..... Turbine room.
Span ..... 88 ft. 4 in.
Capacity ..... 20 T.
Motors ..... All crane type

Bilge pumps, make..... Yeomans Bros. Co.
Type ..... Vertical, submerged
Capacity..... Two 500 g.p.m. and two 750 g.p.m.

Water treating plant, make..... Wm. B. Scaife & Co.
Type ..... We-Fu-Go, intermittent
Reagents ..... Lime and soda ash
Capacity ..... 12,000 gal. per hr.

Elevators, make..... Otis Elevator Co.
Type ..... Push button
In condenser well, capacity..... 1500 lb.
For office building, pass., capacity..... 1500 lb.
For office building, frt., capacity..... 5000 lb.

Insulation ..... The Philip Carey Co.

Valves ..... Crane Co., The Edward Valve & Mfg. Co., Chapman Valve Mfg. Co.

Piping..... Pittsburgh Piping & Equip. Co.

Ash Conveying Equipment—

Transporter, make..... Milwaukee Elec. Crane Co.
Type..... Mono-rail, bucket
Bucket capacity..... 1 yard

Ash disposal pumps, make.....
.....American Manganese Steel Co.
Number 2
Type ..... Centrifugal
Capacity ..... 1500 g.p.m.
Drive ..... 200-hp. squirrel cage motors

Clinker grinders..... ....Westinghouse E. & M. Co.

Fine coal conveyors, make..... Stearns Conveyor Corp.
Number 4
Type ..... Screw
Capacity ..... 12 T. per hr.

Crushers, make..... American Pulverizer Co.

Coal spout swingers..... Henry Pratt Co.

Miscellaneous, Electrical Equipment—

Synchronous condensers, make..... General Elec. Co.
Number 2
Rating ..... 1000 kv.a., 2300 v., 3 ph., 720 r.p.m.
Battery charger, make..... General Electric Co.
Type ..... Motor-generator
Rating ..... 35 kw.

Storage battery, make..... Electric Storage Battery Co.
No. cells 120
Rating ..... 50 amp., 8 hr. rate

Transformer, make..... General Electric Co.
Station service, No..... 3
Connection ..... Delta
Rating ..... 2500 kv.a.
Voltage ..... 11,000/2300 v.
Gaps at..... 11,550; 10,450 and 9900 v.
Cooling ..... self

Distribution, number 4
Rating ..... 15,000 kv.a.
Phase ..... Single
Voltage ..11,000/132,000, with four 2½ per cent taps
Connections .....
..Low voltage delta, and high voltage y, grounded

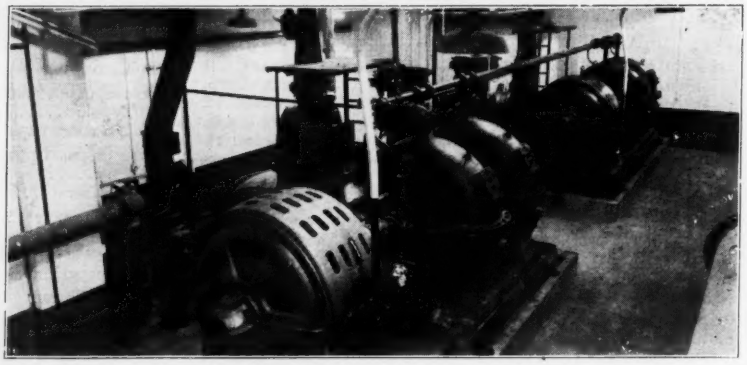
Switchgear, make ..... General Electric Co.

Disconnecting switches ..... Delta Star Elec. Co.

Many Unusual Features Are Found at Philo

These circulating pumps are essentially stand-by units for the reason that for eleven months out of the year the head over the dam is sufficient to force the circulating water through the condensers. The water enters at the top of the condenser, passes downward and then up through the second pass. Sand pumps are provided which need be operated only periodically when foreign matter collects in the lower water chamber of the condenser.

Coal is stored under water in a section of an old barge canal. Railroad cars will be run out on the trestle and dumped and the coal will be spread by a gantry crane which is to be erected in the near future. At the left is shown the dry storage to which coal is delivered by a belt conveyor and is distributed and reclaimed by the traveling crane. This coal fires easily, therefore the first coal stored is the first to be reclaimed. 400,000 T. of coal can be stored at this plant.



Outside light is available on three sides of the operators' room. The partition wall between this room and the turbine room is also fitted with glass so that the operators have a clear vision, not only of the yard transformer and distribution structures, but also of the turbine room. Set in the wall between the boiler and turbine rooms is an instrument board on which are mounted illuminated indicators. Thus the same instruments are seen by the operators in these three rooms.

This station is tied in with other properties of the American Gas and Electric Co. Distribution is made to many of the larger cities in such districts as Toledo, Cleveland, Wheeling and Pittsburgh. Current is generated at 11,000 v. and distributed at 132,000 v. Three lines now leave this structure, which is being added to for a fourth outgoing line. A line is now being constructed between Lima, O., and the new Twin Branch Station near South Bend, Ind.

full length of the lower bank of tubes and then sweep the entire surface of the superheater. A vertical baffle divides the upper bank of tubes so that the gases leaving the superheater pass up through the front portion of these tubes. They then make a 180 deg. turn and come back through the rear portion of the upper tube bank. The gases leave the boiler by passing between the tubes which connect the upper and lower sections of the rear header.

Economizers and Air Preheaters Are Used

Gases leave the boiler setting opposite the superheater and then pass downward through an 8837 sq. ft. B. & W. economizer. They then make a 180 deg. turn and pass up through an air preheater and on to the induced draft fan which is rated at 118,400 cu. ft. per min. Each of these fans, of which there are eight, is driven by either of two variable speed motors of different ratings.

At the present time two steel stacks, each 155 ft. high have been erected. The stack nearest the permanent end of the building is 16 ft. in diameter and is connected to four boilers. The other stack, which is on that end of the building to which future extensions will be made, is 22 ft. 6 in. in diameter, and although it now serves four boilers the next unit of four boilers will also be connected to it.

Forced blast equipment for each boiler consists of one 70,600 c. f. m. fan, driven by either of two motors of different rating. On each side of the firing aisle is a common air duct which connects the three fans serving the standard boilers. The reheat boiler fans are not connected to these ducts. Air for the stokers is taken from near the boiler house ceiling, drawn down through the air preheater, where its temperature is increased about 100 deg. F., and discharged by the forced blast fans into the ducts leading to the stoker air compartments.

General arrangement of the setting, stokers, arches, economizers, air preheating and induced and forced draft is the same for the reheat boilers as for the standard boilers. The difference lies in the design of the boiler which is a combination high-pressure, steam-generating unit and a reheater unit. In this boiler the upper deck of tubes has been omitted, the superheater having been placed above the one tube deck. The steaming capacity of this part of the boiler is 75,000 lb. per hr. at the same pressure and temperature as the standard boilers, thus it is operated in parallel with the three standard boilers of its unit.

Above the cross-drum of the high pressure section is located the reheater section which consists of a series of bent tubes connected to three cross drums. Steam, from the 7th stage of the turbine, enters the lower drum and leaves the top drum reheated to 725 deg. F., returning to the 8th stage of the turbine. There is, of course, no connection between the high and low pressure sections of the reheat boiler except through the first seven stages of the turbine. The normal capacity of the reheat section of the boiler is 310,000 lb. steam per hr.

Boilers on each side of the firing aisle are paired for right and left hand steam connections. One steam header extends along each side of the firing aisle with a crossover, tying the two together at a point near the reheat boilers. Considering the header on one side, connections are made to it between boilers three and four. An expansion bend is placed between boilers two and three and the connections from the other two boilers are made between boilers one and two. The header then drops down through the floor to a receiver-separator, which is anchored. Two long radius bend connections are then made to the turbine throttle. Reheat steam connections between the turbine and the reheat boiler are made up with long radius bends.

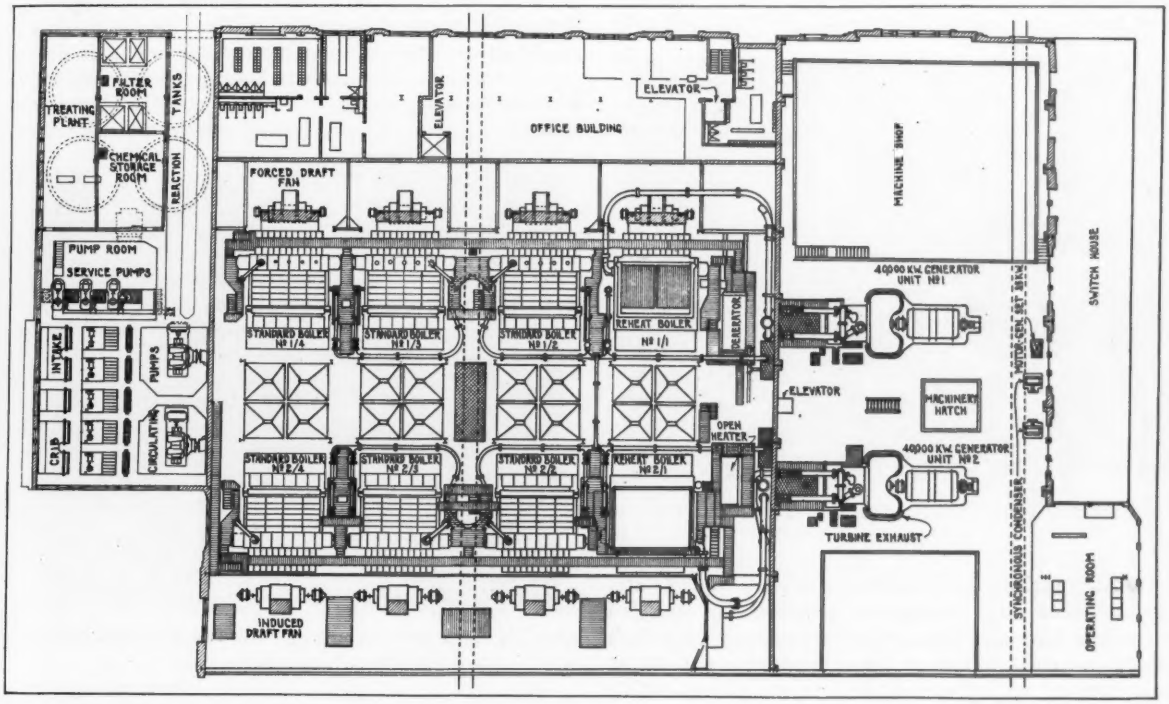


FIG. 12. FOUR BOILERS, THREE STANDARD AND ONE REHEAT, SERVE EACH 40,000-KW. TURBINE UNIT

A valved cross-over in these reheat connections provides for bypassing the reheater, thus expanding the high pressure steam through the 18 stages without reheating. The steam leads are all made of tubing and the joints are of the Sargol type.

Control of boiler operation is entirely within the judgment of the fireman, the only automatic equipment installed being S—C feed water regulators. Each fireman has charge of two boilers, his station being equipped with two control benches. These benches are located one on each side of the firing aisle and at the front of the two boilers which are controlled by each fireman.

Boiler Instruments Are on Control Benches

Equipment provided on each control bench is as follows: manual controls for the stoker motors; remote con-

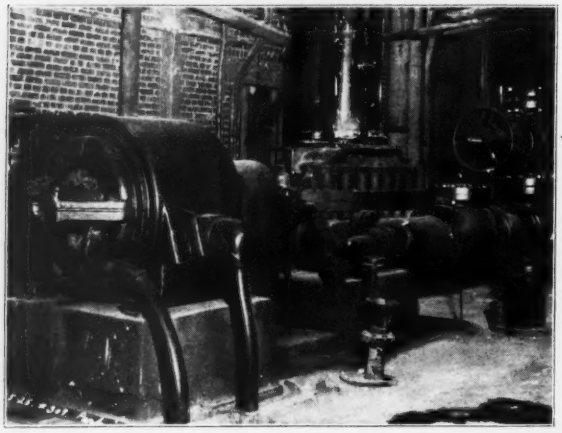


FIG. 13. THIS BOILER FEED PUMP IS DRIVEN BY A 600-HP. MOTOR

trol for the variable speed induced draft fan motors; also for the forced blast fan motors; ammeter for each fan motor; one Ellison inclined-tube draft gage showing draft over fire, at boiler outlet, at the economizer outlet and at the suction of the induced draft fan; one Ellison multitube draft gage to show pressure in the stoker compartments; one Ellison single tube gage to show the pressure in the wind box; three Foxboro recorders for the water temperature to and from the economizer; for the gas temperatures at the boiler outlet, economizer outlet, and air-heater outlet; the draft over the fire and at the air heater outlet; a General Electric indicating flow meter on the boiler feed line.

Each reheater boiler bench is also equipped with a Leeds and Northrup recorder showing gas temperatures in and out of the reheat section of the boiler and an indicator showing the steam temperature leaving the reheater. This latter instrument is of great importance because the firing of the reheat boilers is based entirely upon the temperature of the steam leaving the boiler.

Push button controls in the turbine room enable the operators to open and close the main steam header and the reheat valves. Non-return valves can be closed through push button control from the operating room. The non-return valves can also be closed by push button control from the boiler room office, but to open these valves, the operator must go to a button placed near the valve.

Boiler feed make-up water normally comes from the river and is treated by the Scaife lime and soda ash process in two 50,000-gal. tanks. Water for the turbine oil coolers and transformers is pumped from wells and stored in one of the overhead tanks located north of the building. If the river water is unusually dirty this well or ground water can be reclaimed and treated for use as make-up water. Service pumps deliver the river water to the treating tanks or if ground water is to be reclaimed it is handled by a reclaimed-water pump.

From the treating plant the filtered water flows by gravity into a 400,000-gal. clear well from which it is pumped to a Wheeler Condenser and Engineering Co. quadruple-effect evaporator, which is now normally operated about 8 hr. out of the 24. These evaporators are rated at 40,000 lb. of distilled water per hr. The distilled water is pumped to the overhead emergency storage tank located just north of the main building. Inside the building is an overhead make-up water tank which is drawn upon for normal service. From storage the make-up water flows to the open heater where it is mixed with the condensate. It then flows to the deaerator-separator after

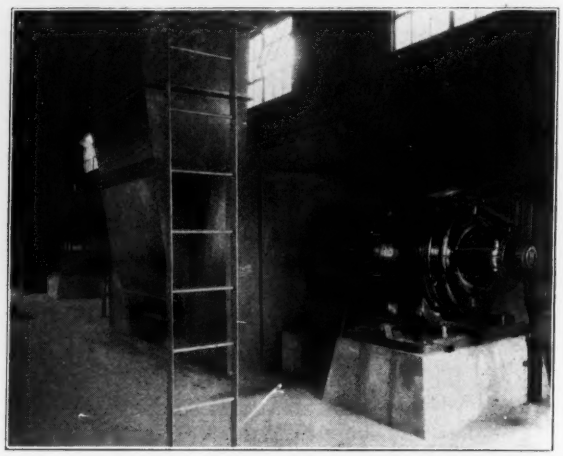


FIG. 14. TWO MOTORS ARE CONNECTED TO EACH INDUCED DRAFT FAN

which it is picked up by the boiler feed pumps and forced through the high pressure economizers to the boilers.

Extraction Steam from 12th and 16th Stages

Condensate is pumped from the hot wells, through the fin-type generator air coolers and then through the after cooler of the steam-jet vacuum pump. It then passes to the evaporator condenser, then to the 16th stage extraction heater, then the deaerator vapor condenser, then to the gland steam heater and finally to the open feed-water heater where 12th stage bleed steam may be added if necessary.

The building is heated by hot water, which is obtained from closed heaters using either 12th or 16th stage extraction steam or live steam reduced in pressure from the 175 lb. auxiliary line which furnishes steam to the steam-jet vacuum pumps.

Four feed pumps have been installed. Two of these are motor driven Cameron pumps, each rated at 750 g.p.m., 1750 r.p.m. and 1500 ft. head and two are Bethlehem Weir-type steam driven pumps. One main feed line runs overhead in front of each line of boilers. These two lines are connected by a cross-over. There is also an auxiliary line on each side which runs beneath the boiler room floor. The main valves in these lines are all bypassed with a ¾-in.

connection and the joints are made up with 1/32-in. Klingerit gaskets.

River and Rail Transportation Available

Coal may be brought to this station either by water or by rail. If the coal is to be stored it is brought in over a track scale at the south end of the submerged storage space. A trestle extends the full length of the storage space, which is long enough to permit running a train of cars out on it and dumped. A traveling gantry crane will be used to spread the coal and also to reclaim it. When reclaiming the gantry will pick up the coal and discharge it into a crusher which travels on a track between the dry and submerged storage areas. The coal will be discharged from the crusher to the dry storage area by a short belt conveyor which is part of the crusher car equipment. The height of the water, which is run in under head from the dam, will not be sufficient completely to submerge the stored coal.

At the south end of the dry coal storage area are two track scales and two track hoppers. An apron conveyor feeds from each track hopper to a crusher house. Here the coal is crushed to about 1½ in. by American Pulverizer Co. ring crushers and is then picked up by a belt conveyor which extends the full length of the dry storage area, discharging into another crusher house at the opposite end. Coal is unloaded at any point from this conveyor and spread out by a traveling crane which also reclaims the coal and loads it on the belt for delivery to the No. 2 crusher house where it is crushed to stoker size and fed into the station by a second belt conveyor feeding the steel and concrete coal bunkers in the boiler house. It is then distributed to the stokers through Phillips' mechanically operated swinging spouts to give a uniform distribution of coal to the stokers. The dry storage capacity is 100,000 T. Siftings from the stokers are not worth saving and are sluiced into the ash tanks. The coal handling equipment is rated at 600 T. per hr. The traveling crane on the dry storage work is operated by d.c. motors, current being furnished by m.-g. sets located in the coal yard sub-station.

Ash is discharged by the stokers into brick-lined, steel hoppers. It is then fed through clinker grinders to the sluiceway and washed to either of two storage tanks. From one of these pits the ash is pumped and used to fill adjoining property. The other pit is within reach of an overhead traveling crane which will load railroad cars by means of a grab bucket. Normally it is expected to remove the ash by pumping.

Practically All Auxiliaries Are Motor Driven

It is interesting to note that all auxiliaries are motor driven except two boiler-feed pumps and the steam-jet vacuum pumps. The only d.c. motors about the station are those driving the stokers, valve mechanisms and those on the one coal storage crane. All squirrel cage induction motors up to 250 hp. are thrown directly across the line as are slip ring induction motors up to 600 hp. One turbine unit has now been in operation since October, 1924, and it has not been necessary since that time to clean the condenser.

This station was built for the Ohio Power Co., a subsidiary of the American Gas & Electric Co. of which R. E. Breed is chairman of the board, Geo. N. Tidd is president, E. A. Johnsen is mechanical engineer and M. L. Sindeband is electrical engineer. E. H. McFarland is manager and J. A. Bergin is superintendent at the Philo Station. Sargent & Lundy, engineers, designed the station in cooperation with the engineers of the American Gas & Electric Co.

Superheated Steam in High Pressure Underground Lines

By L. A. Foster

USE OF SUPERHEAT in the transmission of steam in underground high-pressure steam lines is probably one of the most interesting recent developments. Its introduction has, of course, necessitated a change in the general design and construction of underground steam mains, so that the mechanical features are now practically the same as those used in a modern power plant. Superheat, in conjunction with steam pressures varying 100 to 250 lb., has been used in recent years, underground, with complete success and security.

Reducing condensation in long pipe lines is a problem which is faced in many instances. Keeping in mind that approximately 90 per cent of the heat necessary to evaporate water is latent heat, it is evident that this is wasted when condensation takes place. The adoption of superheat will eliminate this waste and cut the loss considerably; in fact, it is entirely possible to carry steam underground for great distances with no condensation losses. There is, of course, a loss in heat, but it can be confined strictly to loss of superheat, and this loss is considerably less than that in the case of saturated steam. Loss of heat from a pipe conveying saturated steam does not result in a change of temperature but results in the condensation of a portion of the steam. In the case of superheat, the loss of heat results in a lowering of the temperature of the steam or a loss of superheat, which means that condensation will take place only after all the superheat has been dissipated.

To get a clear picture of the application of superheat to transmission of steam underground, it is interesting to note the following example of actual performance of an underground line of considerable length.

Referring to the table, column 1 shows the hourly flow of steam as metered and column 5 the superheat initially, while to the right in column 9 is shown the superheat remaining in the steam at the terminal end of the line, also in 10 and 11 the actual loss in degrees of superheat and the pressure drop. Note that, with increase of steam flow per hour, the loss of superheat decreases, hence, it is evident that loss of superheat varies inversely with the quantity of steam flowing. In this instance, if the flow of steam per hour is kept above a certain point, superheat will be delivered at the terminal end of this line and no condensation loss will take place.

Now to illustrate and compare the above superheat loss with condensation loss, such as takes place when saturated steam is flowing through an underground pipe, the writer can quote some actual figures from an installation, the general conditions of which are as follows:

Initial pressure, saturated steam, 175 lb. sq. in.
Length of line 1200 ft. of 14 in. pipe; 1200 ft. of 12 in. pipe; 1200 ft. of 10 in. pipe; total 3600 ft.

In the above line, the actual metered condensation loss for one hour was 1232 lb.

It is not possible to compare the relative value of the heat losses in dollars and cents, as the two lines mentioned are of entirely different construction and manner of insulation, and located in widely separated parts of the country. Both lines are of good design and operating efficiently. The general thought here is to show that, in

this particular instance, steam is carried approximately twice the distance without condensation loss by utilizing superheated steam. It must be remembered, also, that the line carrying superheated steam can deliver dry and superheated steam, while the line carrying saturated steam could do so only in a limited manner.

To compare the relative effects of heat transmission losses for superheated and saturated steam expressed in B.t.u. lost per hour per sq. ft. per degree difference in temperature (often designated by the value K), the following data are of interest. In an Eastern City a test was run on a 10 in. high-pressure line which is 1250 ft. long and fortunately was so connected at the power house that either saturated or superheated steam could be supplied. (See N.D.H.A. Proceedings 1923, Page 121.)

The following is a brief outline of what this test showed relative to this subject:

LOSSES IN UNDERGROUND LINE USING SUPERHEATED STEAM

Power Plant					End of 12 in. Line, 6,175 ft. Long						
Actual Flow Lb. of Steam Per Hr.	Gage Pressure Lb. Sq. In.	Saturated Temperature Deg. F.	Actual Temperature Deg. F.	Superheat Deg. F.	Gage Pressure Lb. Sq. In.	Saturated Temperature Deg. F.	Actual Temperature Deg. F.	Superheat Deg. F.	Loss in Superheat Deg. F.	Total Pressure Drop Actual Lb. Sq. In.	Drop in Pressure Per 100 Ft. Actual Lb. Sq. In.
150,000	220	396	549	153	143	363	480	117	36	77	1.25
125,000	228	398	542	144	173	377	467	90	54	55	.89
100,000	230	399	540	141	191	384	462	78	63	39	.63
75,000	232	400	539	139	206	390	455	65	74	26	.42
50,000	235	401	534	133	217	395	426	31	102	18	.29
25,000	238	402	508	106	228	398	398	0	106	10	.162

	Saturated Steam	Superheated Steam
Pounds of condensation per hour	303.5 lb.	None
B.t.u. lost per hour per sq. ft. per degree of temperature difference, or K.	0.219 lb.	0.113

Note the B.t.u. loss per hour per square foot per degree difference in temperature for superheated steam is only 51.5 per cent of that for saturated steam. In this instance, there was no condensation produced when superheated steam was used. This again illustrates the advantage gained by the use of superheat in preventing loss of latent heat. The particular line mentioned is suspended overhead and, in its route, crosses a river to serve a manufacturing plant.

The following table shows the locations of installations which are using superheated steam in underground high-pressure steam lines.

City	Steam pressure used lb. sq. in.	Degrees of superheat used
Portland, Oregon	230	135
Erie, Pa.	250	200
St. Louis, Mo.....	185	100
Arkansas City, Ark....	150	170

The writer most certainly does not want to give the impression that superheat should be used in every steam line installed underground, as the use of saturated steam in underground lines has its rightful place in some instances. The character of the equipment, the load to which the steam is delivered and the purposes for which it is used should determine which method to adopt.

BLOWOFF LINES should be scraped and painted once every three months. They should be given one coat of red lead and three coats of ebonite.

Chemicals Used for Softening Water

MANY INSTANCES have occurred where confusion has resulted from the purchase of water treating chemicals which were not entirely adaptable to the purpose intended of them. That chemical which requires the most care in purchasing is lime. The reason for this is that there are many grades of lime on the market which contain less than 90 per cent of hydrated lime. It is always advisable when purchasing to specify "hydrated" lime containing not less than 90 per cent calcium hydroxide, $Ca(OH)_2$. Lime which contains more than 3 per cent of magnesium salts should be avoided.

Lump lime works to the user's disadvantage in two ways. First, it frequently contains unburned rock which makes it impossible to weigh accurately the correct quantity for softening the water. Secondly, these pieces of unburned rock may lodge in the pumps and agitators and small pieces will find their way into the chemical proportioner, thus interfering with the proper feeding of the chemicals. Although hydrated lime costs more per pound than does lump lime the hydrated product will give much more satisfactory results and it will be the more economical in the long run.

Soda ash as used for water softening is composed of 62.1 parts of sodium oxide and 44 parts of carbon dioxide. These combine to form 106.1 parts of sodium carbonate, Na_2CO_3. The term "58 per cent" refers to the proportion of sodium oxide which is contained in the product and therefore it corresponds to soda ash containing 99.1 per cent sodium carbonate. Dividing 62.1 by 106.1, we get the result 0.58 or 58 per cent. It is advisable when purchasing to specify "58 per cent soda ash."

Soda ash may contain less than 58 per cent sodium oxide, in which case the difference is represented by impurities which are ineffectual as softening agencies. In fact, these impurities may unnecessarily add to the soluble salts which are present in the softened water.

Caustic soda is the third chemical which is often used for softening water. It is composed of 62.1 parts of sodium oxide and 18.016 parts of water. The term "76 per cent" refers to the ratio of sodium oxide contained in the product. This corresponds to 98 per cent caustic soda. Caustic soda is shipped in steel drums which weigh from 500 to 700 lb. It is also possible to obtain it in the granulated form, in which case it is shipped either in drums or barrels. As a matter of convenience the granulated form is usually preferred, because the portion required can be transferred easily from either the drum or the barrel to the chemical tank.

Radiation in the Pulverized Fuel Furnace*

Furnace Design and Size of Fuel Particles Determine Rate of Heat Absorption. By Walter J. Wohlenberg and Donald G. Morrow

IN THE discussion of the fundamentals of radiation in the pulverized fuel furnace it is shown that the radiating power through the flame surface depends primarily

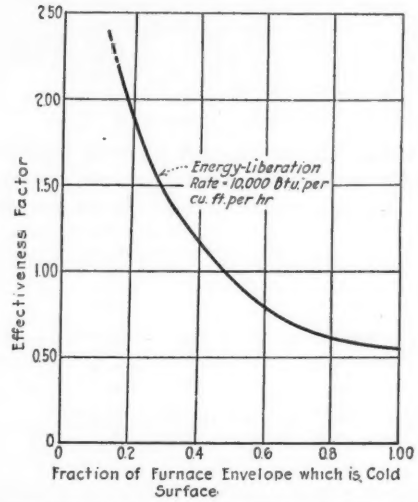

Effectiveness Factor
Energy-Liberation Rate = 10,000 Btu. per cu. ft. per hr
Fraction of Furnace Envelope which is Cold Surface

FIG. 1. VARIATION OF EFFECTIVENESS FACTOR AND FRACTION OF FURNACE ENVELOPE WHICH IS COLD SURFACE

on the size of the particle and that, based on the flame-surface area, its magnitude relative to black radiation is low. The heat absorption intensity at the cold surface, however, may be considerably higher than the relative radiance of the flame. This factor depends on both the amount and disposition of the refractory furnace lining.

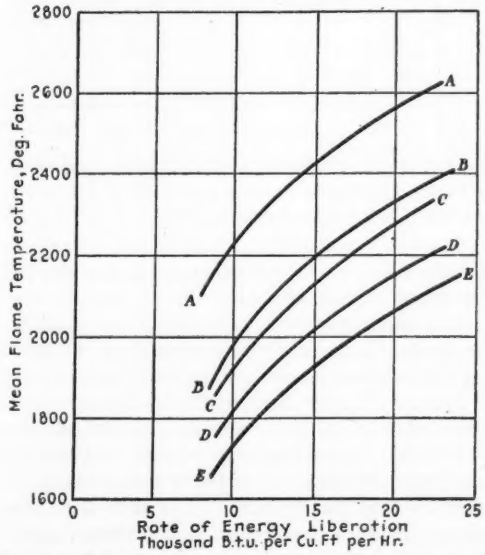


FIG. 2. VARIATION OF MEAN FLAME TEMPERATURE WITH RATE OF ENERGY LIBERATION

Application of the method outlined enables, by an analytical process, quantitative evaluation of the furnace energy process and the data yielded are of such a nature as to indicate by comparison which furnace proportions will give the best results.

Usually the subject of radiation involves such difficulties in evaluation that it is dismissed with little thought. Even when calculations are attempted, such important factors as reflection and radiation from the refractory, interference offered by the gaseous and solid particles of the flame and certain other influences are neglected, so that the result has been a hazy notion of the energy process involved.

Types of Furnace Design

To determine the effect of relation of cold surface to refractory surface, five arrangements of furnace design

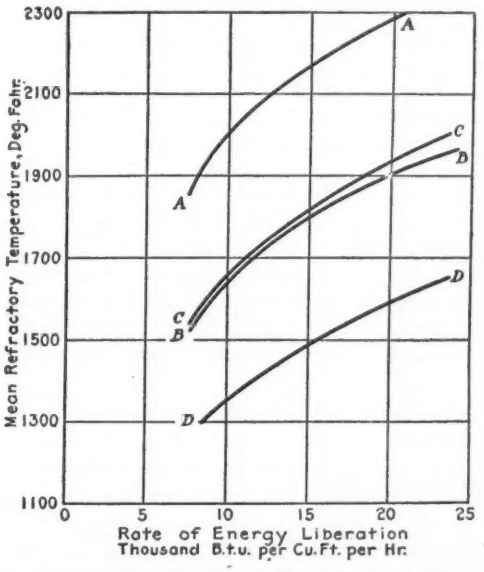


FIG. 3. VARIATION OF MEAN REFRACTORY TEMPERATURE WITH RATE OF ENERGY LIBERATION

were studied, as follows: A. Cold surface at the top face only which forms aperture for escaping gases; B. Cold surface at top and bottom faces, escaping gases at top; C. One-half of interior surface as cold surface, distributed so that one-half of top, bottom and two sides, and entire furnace back is cold surface; D. Top, bottom, and two opposite sides as cold surface; E. Furnace totally enclosed by cold surface.

Comparison of Furnace Types

In furnace C, there is more cold surface than B but the flame temperature of C is only slightly lower than B and, contrary to expectations, the refractory temperature of C is actually higher than B. The result is only a slightly greater heat absorption for C. This is true because in C there is too much cold surface at one point with insufficient distribution of refractory surfaces. This is shown graphically by Fig. 1.

Figures 2 and 3 show variations in flame and refractory temperature, with rate of energy liberation. These show a gradual increase of energy liberation as the temperatures

*Abstract of a paper presented at the Spring Meeting of the A.S.M.E., at Milwaukee.

increase. This means that a larger part of the liberated energy must be absorbed in the convection zone of the boiler and hence efficiency must necessarily decrease. For a large fraction of refractory surface the re-radiated and

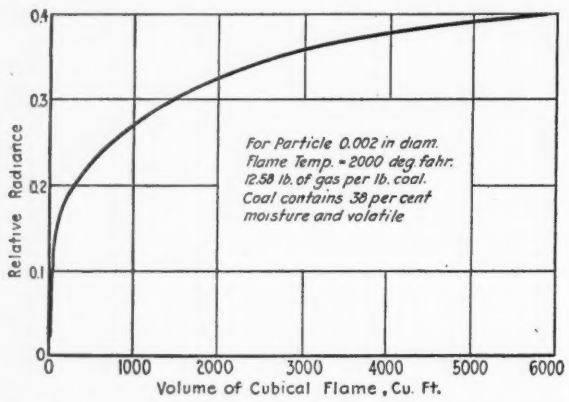


FIG. 4. VARIATION OF RELATIVE RADIANCE WITH FLAME SIZE

reflected energy adds to the direct radiation discharged from the flame to the cold surface.

Influence of Pulverization and Flame Volume on Relative Radiance

Curves of Figs. 4 and 5 illustrate the variation of the relative radiance with flame and particle size. By relative radiance is meant the radiation intensity of the flame surface compared to that of a block body. With 75 per cent of the fuel through a 200-mesh screen, the variation of

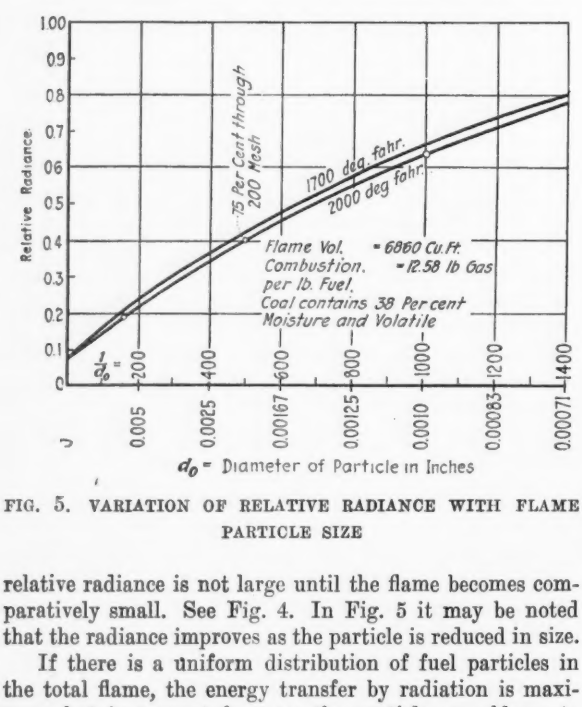


FIG. 5. VARIATION OF RELATIVE RADIANCE WITH FLAME PARTICLE SIZE

relative radiance is not large until the flame becomes comparatively small. See Fig. 4. In Fig. 5 it may be noted that the radiance improves as the particle is reduced in size.

If there is a uniform distribution of fuel particles in the total flame, the energy transfer by radiation is maximum but in present furnaces the particles are blown to the flame as a dense central cloud which later on becomes distributed throughout the flame mass. As compared to that in a uniform mixture, the actual radiation interference fraction, or shielding coefficient, will thus be large in the flame zone near the burner. The total radiance is decreased but relative radiance is increased.

As the gases travel farther along the flame path the fuel-air distribution is better, and at the point of change of direction the turbulence becomes greatly increased with a resulting maximum rate of energy liberation, so that, in spite of the decreased shielding of the particles, the flame temperature is maximum. The radiation discharge from this zone is probably likewise a maximum.

In Fig. 6 it is interesting to note the relation between screen mesh and the size of the fuel particle.

Oxygen Intensity

The surface oxygen intensity (pounds of oxygen combining with carbon per hour per unit surface exposed by particles) has been assumed constant as the particle travels

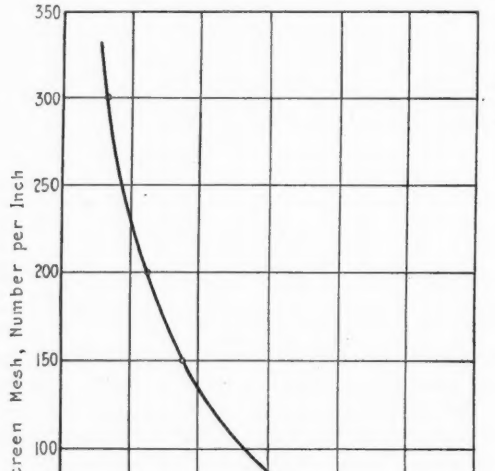


FIG. 6. RELATION BETWEEN SCREEN MESH AND DIAMETER OF PARTICLE WHICH PASSES THROUGH WITH 10 PER CENT CLEARANCE

through the furnace. Actually this factor is greatest where the gas travel changes direction.

Oxygen intensities and, accordingly, rates of energy-liberation, should be nearly proportional to the quantities of oxygen contained per unit volume of the burning gases in the furnace. Energy liberation rates for poor gases and rich gases should not differ greatly. Investigation shows even when high volatile coals are burned, that the required volume oxygen intensity is far below that actually realized in furnaces where gas is burned. The burning of the volatile matter should not, therefore, at the present time limit the energy liberation rate in pulverized fuel furnaces.

With most common methods of burning pulverized coal in boiler furnaces, the energy liberation rate is not much over 20,000 B.t.u. per cu. ft. per hr.

The limiting mean velocity between particles and the flame is not much greater than 1 to 2 ft. per sec. As the particles are decreased in size, the ratio of surface to

weight per particle increases, whence the tendency will obviously be to reduce still further the relative velocities and hence oxygen intensities, unless some other than the usual methods of creating turbulence can be found which is commercially satisfactory. If two flames should be directed one toward the other, the relative velocities would obviously be tremendously increased.

In the oil furnace a higher initial particle velocity is obtained by pressure, but this method does not lend itself to the pulverized-fuel system. Burners with perhaps a centrifugal discharging jet of high velocity may, when properly designed offer a solution. With present systems, however, it becomes apparent that finer pulverization will probably not increase the rate of energy liberation, because as the particle surface is increased the oxygen intensity will decrease.

Obtaining Better Service from the CO_2 Recorder

Suggestions for Selecting Recorder and Installing Sampling and Connecting Piping. By A. P. Nutter

GRANTING THAT a constant knowledge of CO_2 percentages in flue gas offers a reliable means for checking furnace efficiency, it should be unanimously conceded that an instrument capable of accurately recording such information is an unusually valuable piece of equipment. To readers who wish to reassure themselves on this point, the January 1, 1923 issue of Power Plant Engineering offers some interesting reading. The Bureau of Mines also publishes a variety of bulletins on the subjects which contain a lot of "meat." These bulletins may be obtained from the Department of the Interior at small cost.

Realizing, as the majority of progressive engineers do, that the CO_2 recorder is indeed worthy of careful consideration, it is disturbing to note that too often this particular outfit is kept in operation but a short time before being relegated to the junk pile. An article I have in mind states that a certain instrument (CO_2 Recorder) once installed will perform its duties faithfully and without interruption, for an indefinite period, with practically no care or exertion on the part of the engineer in charge. It is true that the present day CO_2 recorder has been simplified and refined to a point where only slight attention is required. Nevertheless, it has not reached, and is not likely to reach, such a stage of perfection as to require absolutely none.

Accordingly, bear in mind that, regardless of claims to the contrary, the service you get from your recorder depends largely on its care and manipulation. It is one thing to look on while a demonstrator sets up the outfit and starts it going and quite another to keep it in operation after he has gone.

Simplicity of Construction Should Be Considered

In selecting a recorder, I believe that the main factor to be considered is simplicity. There are several good CO_2 recorders on the market, including those which employ the following methods of determination: thermal conductivity, interferometer, density balance, direct weighing and volumetric determination. The prospective purchaser must use judgment in making a selection, picturing in his mind's eye what precautions he will be obliged to take and how many loose nuts there will be to tighten. Again I would strongly advise selecting according to simplicity. It has been my experience that the average boiler plant instrument man is not adept at weighing out so many c.c. of this or that, nor is he able to tell by smelling or tasting whether or not his solutions are up to standard. Accordingly, I would look with disfavor on any recorder which required the services of a chemist for its successful operation.

Apart from this consideration is that of maintenance costs. What parts are liable to wear out and what will it cost to replace them? These are fair questions to ask. Last, but not least, what assurance is there that accurate records will be obtained, and if so, for how long a time?

In order to attempt to assist the interested operator in "hooking up" and arranging his recording equipment so as to obtain reliable readings, I am going to mention a few points which have come to my attention. Assuming that the new recorder has arrived in good condition and has been carefully removed from its box, the first thing to consider is where to locate it. Regardless of the make, locate it as near the boilers as conveniently possible. This advice applies particularly to instruments employing the absorption principle for their operation, since long pipe lines will increase the lag between the time at which gas enters the sampling tube and that at which the CO_2 percentage is recorded. Such a condition is sure to confuse the firemen who are gaging furnace conditions at a given time by the CO_2 reading, supposedly recorded at that instant. A hole in the fuel bed will cause excess air and a resultant drop in CO_2. Accordingly, it is imperative that the recorder indicate this condition immediately, otherwise the fireman is likely to be misled.

Another factor in favor of locating near the boilers is the question of arranging and supporting pipe lines so as to prevent pockets and sags. The minimum number of joints is always desirable. As to the objection to sags in the pipe line, condensed water vapor is common to the average run of flue gases. Accordingly, every sag in the gas line offers a resting place for this vapor, with the result that the line becomes plugged and no gas reaches the recorder.

Locating the Sampling Pipe

Having selected a location for the recorder and charted out the most desirable route for the gas line, the next step is to install the sampling pipe. If you had planned to use an open end single tube, let me suggest that you abandon the idea. The only good thing about this type of sampler is its simplicity. It is easily installed and can be cleaned readily, but it will also plug almost as fast as you can clean it; moreover, you cannot hope to obtain with it a representative sample of gas. This factor is of extreme importance and should be given careful thought in locating the sampling tube, regardless of the style employed. The sampling tube extending across uptake and provided with several small openings along the tube gives a fair representation of the composite gases given off. This style also becomes plugged easily.

To my mind, the porous filter offers one of the best methods of obtaining clean gas over an extended period. Like any other device of this kind, however, it does re-

quire a certain amount of care and attention, but only such as might reasonably be expected on any equipment exposed to unusually severe conditions. I believe that I am correct in stating that the majority of trouble experienced in operating CO_2 recorders can be justly attributed to lack of reasonable care of the sampling equipment.

Pipe connections should be made of standard ¼ in. iron (not steel) pipe, with cast iron fittings where they are absolutely necessary. Avoid fittings as much as possible by bending the pipe. Care should be used, however, not to flatten the pipe in bending. Joints should be made tight and tested with compressed air before connecting to the recorder. Use nothing but ground, air-tight cocks for manifolds or other distributing outlets. In general, give the installations as much consideration as you would your automobile when you overhaul it to stop some imaginary squeak or rattle. Bear in mind that you are dealing with small quantities of gas and that leaks caused by poor workmanship will render your recorder useless.

When the installation is completed and the pen is making a nice, red line at about 14 per cent, don't throw away your instruction book and forget all about the sampling tube until the red line is a meaningless splotch, but keep on your toes. Tend to your recorder as religiously as you do your boilers. Don't take too much for granted. Check it up occasionally with your hand Orsat, but first check your Orsat and draw your gas sample from the same source as your recorder takes it.

Above all, make use of your CO_2 recorder. Interpret your charts and attempt to build up your furnace efficiency through the knowledge obtained from noting tendencies. When you make a change in firing methods or draft, note whether or not your recorder registers progress. Explain to your firemen what it's all about and start some competition for high CO_2. However, don't make the same mistake that the writer did by not explaining why there is such a thing as getting it too high. But impress it on their minds that the recorder is there to help them, to make it easier for them to keep up steam. If they are the kind of men you want in your plant, they will co-operate with you and your recorder will certainly prove its worth.

Expansion Joints Absorb Pipe Movement

NUMEROUS CONDITIONS ARISE IN PIPING WORK WHERE IT IS ADVANTAGEOUS TO USE AN EXPANSION JOINT RATHER THAN PIPE BENDS

EXPANSION AND contraction of piping can and often do give a great amount of trouble in the power plant. The expansion of pipe materials cannot be eliminated, therefore steps must be taken to provide for their occurrence so that they will not be the causes of interruption of service. The direct causes of piping troubles of this nature are faulty design, poor construction or a change of conditions, such as might occur if an existing plant is changed over from saturated steam to superheated steam.

FIG. 1. SWIVEL JOINTS PROVE SATISFACTORY WHEN MADE WITH A FITTING OF THIS KIND

When a metal is heated, it expands in all directions; however, the expansion in diameter of pipe is of so small consequence that it may be neglected. The lengthwise expansion is the troublesome characteristic of pipe and is the one with which the designer is concerned when providing for the increase of temperature within a pipe. The amount of expansion depends upon the rise in temperature, the length of the pipe and the coefficient of expansion which varies with the temperature and is also different for various metals.

The coefficient of expansion may be defined as the increase of length in inches per degree increase of temperature. The range of temperature referred to is the difference between the temperature of the air surrounding the pipe and the temperature of the substance within the pipe. Thus, if we had steam at a pressure of 100 lb. ga. our steam tables would show that it was at a temperature of 338 deg. F. and if the temperature of the air surrounding the pipe was 68 deg. F. the temperature difference to be used in computing the expansion of a pipe through which this steam was conveyed would be 338 — 68 or 270 deg.

Coefficients of expansion for various metals in inches per inch of length at common temperatures, are as follows:

Brass	0.000,010,5
Copper	0.000,009,5
Wrought Iron	0.000,007,5
Steel	0.000,007,2
Cast Iron	0.000,006,2

Thus, if we wished to find the increased length of a 100-ft. steel pipe, which was conveying steam under the above conditions, we would have—

$100 \times 12 \times 0.000,007,2 \times 270 = 2.33$ in. of expansion. In the above expression the figure 12 is used simply because the 100 ft. length must be expressed in inches so it will be in a like unit with the coefficient of expansion which is expressed in inches. It should be noted that neither the diameter of the pipe nor its weight, that is standard, extra heavy or double extra heavy, have anything to do with the linear expansion of the pipe.

For convenience, we may express this as in an equation as follows:

$$E = L \times 12 \times K \times (T - t)$$

in which E equals the linear expansion in inches, L equals the length of the pipe in feet, K equals the coefficient of expansion, T equals the temperature of the substance in the pipe and t equals the temperature of the air surrounding the pipe. The temperatures should be expressed in degrees Fahrenheit. A number of reference books give tables, similar to the one given herewith, showing the expansion of pipe in inches per 100 ft. of length. The expansion for any length of pipe may be found from this table by taking the difference in increased length at the minimum and maximum temperatures, dividing by 100 and multiplying by the length of the pipe expressed in feet.

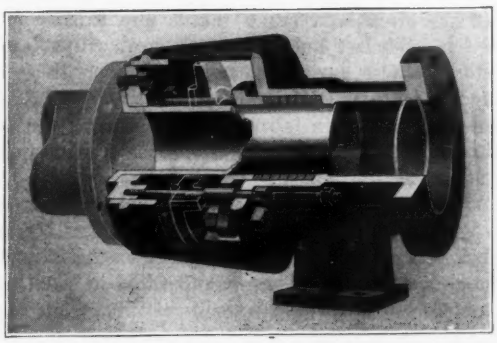


FIG. 2. TIE RODS ARE OFTEN USED TO PREVENT THE JOINT FROM OVER TRAVELING AND OPENING UP

Thus, if we had a steel pipe 1000 ft. long, which varied between the temperatures of 300 deg. F. when hot and 60 deg. F. when cold, the expansion would be (from the table)

$$\frac{(2.50 - 0.45) \times 1000}{100} = 20.5 \text{ in.}$$

See Crane pg. 258 for table.

Expansion in a pipe line may be taken care of by any one of three means; namely, (1) long sweep pipe bends, (2) swivel joints and (3) expansion joints. It is the purpose in the remainder of this article to treat only of the two latter means. It is not meant by this that they are recommended in preference to the long sweep bend, but rather to show their applications, of which there are many, in piping problems. The long sweep bend is of inestimable value on high pressure lines where there is ample room for its installation. It is also used on low pressure steam work and on feed water lines; however, many conditions arise, such as anchorage problems, requirements of lateral service branches, limitations of space and convenience, which call for the use of the other types of expansion joints. A further use for the expansion joint is between prime movers and their condensing equipment or between the condensing equipment and some of its major auxiliaries, such as the circulating pumps.

Swing joints have their application only for small and unimportant work and at the lower pressures. As usually made, they consist of an offset in the pipe, which is made up of standard screwed fittings so that as expansion takes place the fittings will turn on the threads and thus relieve the strains. An expansion joint of this same type can be made of special fittings called "swivel joints." These joints consist of a flanged sleeve, which can rotate in but cannot pull out of the body of the joint. Packing holds the joint steam or water tight. Two of these joints, one placed on each vertical leg of an offset, will make this offset effective in taking up expansion without dependence

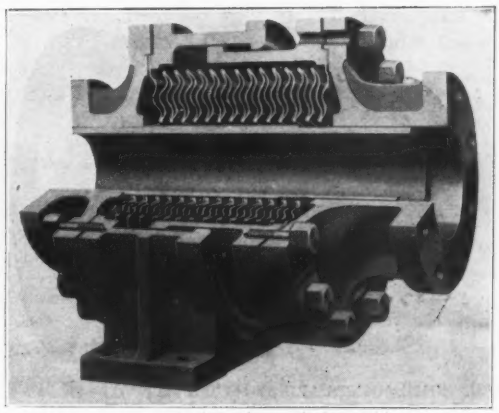


FIG. 4. THIS TYPE OF SLIP JOINT DOES NOT REQUIRE PACKING

upon fittings turning on their threads. Swivel joints may be obtained for saturated steam working pressures up to 250 lb. and in sizes from 3 in. up to and including 16 in.

Expansion joints of the type that are inserted directly in the line may be classified first as to whether or not they require packing and second according to their use or working conditions. The type of joint which must be packed is often referred to as a slip joint. These expansion joints which do not need to be packed may be further classified according to the material from which they are made.

Expansion joints of the sleeve or packed type can be obtained for practically any purpose and for all conditions, the simplest form being that of the all brass joint made for screwed connections, from ½ in. up to 3 in. and for steam working pressures up to 125 lb. ga. The ordinary traverse, or allowable movement of these joints, ranges from 2 to 2¾ in., although a longer traverse may be had if required.

Iron body, brass sleeved and flanged joints of this type may be had in sizes 2 to 6 in. and for pressures up to 125 lb. steam working pressure. Standard traverses range from 2½ in. for the smaller sizes up to 10 in. on the larger sizes. Special traverses can also be obtained. Slip joints can also be obtained from 2 in. up to 48 in. for steam pressures up to 250 lb. ga. and for 300 deg. F. superheat. They can also be obtained for 350 lb. steam pressure, 800 deg. F. total temperature and in sizes from 4 to 12 in.

Slip Joints Must Be Installed Properly

It can readily be recognized that a slip joint is a dangerous thing unless the pipe is securely anchored and cannot over travel the traverse for which it was designed. The expansion between anchors must be within the limits of the traverse. To safeguard against a joint of this kind opening up, many of them are designed with tie rods, the

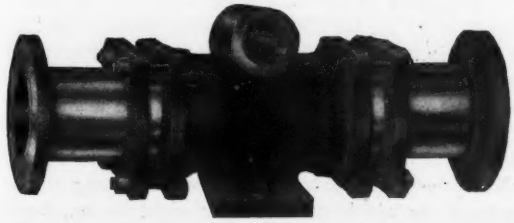


FIG. 3. SLIP JOINTS CAN BE HAD WITH ANCHOR BASE AND LATERAL CONNECTIONS

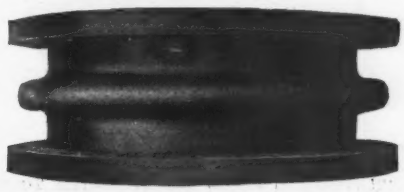


FIG. 5. SOME COPPER EXPANSION JOINTS ARE MADE WITH A SINGLE CORRUGATION

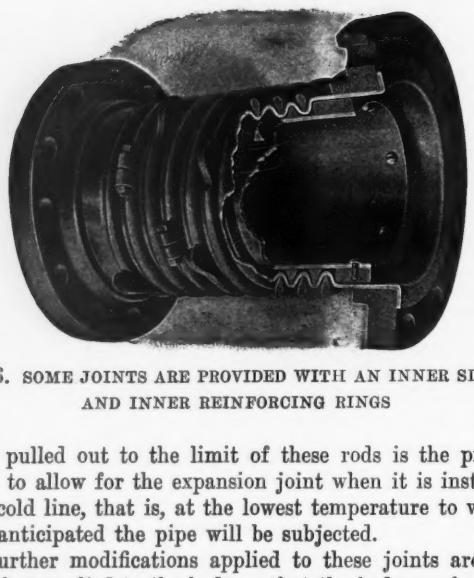


FIG. 6. SOME JOINTS ARE PROVIDED WITH AN INNER SLEEVE AND INNER REINFORCING RINGS

joint pulled out to the limit of these rods is the proper space to allow for the expansion joint when it is installed in a cold line, that is, at the lowest temperature to which it is anticipated the pipe will be subjected.

Further modifications applied to these joints are anchor feet applied to the body so that the body can be held from moving and all of the expansion taken by the movement of the sleeve. They are also built in the double type, which is in reality a double joint with one body provided with an anchor base, thus expansion from both directions may be taken up at the one point. This type is often used in manhole installations where it is most convenient to anchor the pipe at some point between manholes.

It can readily be appreciated that any packed joint should be held fairly rigid and should not be subjected to a strain which will throw the sleeve and body off the same axis. For this reason some expansion joints of the slip type are so constructed that the sleeve is rigidly guided and held in alinement so that it can have no lateral movement, thus it does not absorb any of the warping strains of the pipe. The fact that a joint is so constructed does not mean, however, that anchors and guides should not be used to hold the pipe in good alinement. On vertical runs the anchors should be strong enough to support the weight of the pipe.

Double expansion joints may also be had with a lateral service branch, thus avoiding tapping of the main line at or near the joint. An anchorage base for the joint should, of course, be provided when this type of installation is made.

FIG. 7. REINFORCING RINGS ADD STRENGTH TO THE JOINT AND EQUALIZE THE MOVEMENT BETWEEN CORRUGATIONS

It has often been found that a slip expansion joint placed in an offset line, say at 45 deg., will not be satisfactory because during the traverse there will be a tendency to cramp the joint. This condition can be largely overcome if the main is securely anchored at the branch so that expansion can act only along the true axis of both the main and the branch.

Some types of expansion joints do not require packing. One type of this kind consists of a number of corrugated steel discs alternately welded together at their inner and outer circumferences. These may be had in sizes 2 to 14 in. and for steam pressures up to 250 lb. High pressure joints of this kind have a movement of 2 in. and the lower pressure joints have a movement of about 3 in.

Another form of the joint which does not require packing is the corrugated copper type, which may be made with one or more corrugations. This joint with a single corrugation will have a movement of but ½ in. in the larger sizes and is designed for about 25 lb. steam pressure. This type of expansion joint is often placed between the turbine nozzle and the condenser and it can, therefore, be obtained in practically any size or form to conform to this use. They are sometimes reinforced on the inside to prevent their collapse due to atmospheric pressure.

EXPANSION OF STEEL PIPE, INCREASE IN LENGTH, INCHES PER 100 FT.

Temperature, Degrees F.	Steel	Wrought Iron	Cast Iron	Brass and Copper
0	0	0	0	0
20	15	15	.10	25
40	30	.30	25	45
60	.45	45	40	65
80	.60	60	55	90
100	.75	80	.70	1 15
120	90	.95	.85	1.40
140	1 10	1 15	1 00	1 65
160	1.25	1 35	1.15	1 90
180	1 45	1 50	1.30	2.15
200	1 60	1 65	1.50	2.40
220	1 80	1 85	1 65	2 65
240	2.00	2.05	1 80	2 90
260	2.15	2.20	1 95	3 15
280	2.35	2 40	2 15	3 45
300	2.50	2.60	2 35	3 75
320	2.70	2 80	2 50	4 05
340	2 90	3 05	2 70	4 35
360	3 05	3.25	2.90	4 65
380	3 25	3 45	3 10	4 95
400	3.45	3.65	3 30	5 25
420	3.70	3 90	3 50	5 60
440	3 95	4 20	3 75	5 95
460	4 20	4 45	4 00	6 30
480	4.45	4 70	4 25	6 65
500	4.70	4 90	4.45	7 05
520	4 95	5 15	4.70	7 45
540	5.20	5 40	4 95	7 85
560	5.45	5 70	5.20	8 25
580	5.70	6 00	5.45	8 65
600	6.00	6 25	5.70	9 05
620	6 30	6.55	5.95	9 50
640	6 55	6 85	6.25	9 95
660	6 90	7 20	6.55	10 40
680	7 20	7 50	6 85	10 95
700	7 50	7 85	7 15	11 40
720	7 80	8 20	7 45	11 90
740	8.20	8.55	7 80	12 40
760	8 55	8 90	8 15	12.95
780	8.95	9 30	8.50	13.50
800	9 30	9.75	8 90	14.10

Crane Co.

Corrugated copper expansion joints can be obtained in sizes 3 to 14 in. for 150 lb. working pressure and in sizes 16 to 24 in., 125 lb. working pressure and for temperatures not exceeding 375 deg. F. The construction consists of an annealed, corrugated copper cylinder and a smooth, hard brass cylinder fitted within the corrugated copper cylinder. Inside and outside rings of cast iron serve to equally distribute the movement to be absorbed among the several corrugations which number from eight to ten, depending on the size of the joint. The inside sleeve supports the weight of the parts of the joint and avoids distortion; the

inside sleeve also protects the soft copper cylinder from injury from high velocity steam and reduces the friction loss or resistance to flow throught the joint.

Still another type of expansion joint is that which makes use of rubber as the flexible material. These are made in various forms, one of which is made with an external rubber sleeve, reinforced with metal flanges. The sleeve is fastened securely around its ends by means of strap iron with numerous studs and nuts holding it in place to insure a tight joint. The sleeve is made of material similar to a fabric automobile tire and is of ample cross section to withstand the service to which it is to be subjected. This flexible sleeve being held fast to the collar moves with it as the parts vibrate, approach or recede axially. The collar or reinforcing flanges are of heavy material to sustain the sleeve against whatever atmospheric pressure may be exerted due to the high vacuum existing on the inside of the joint.

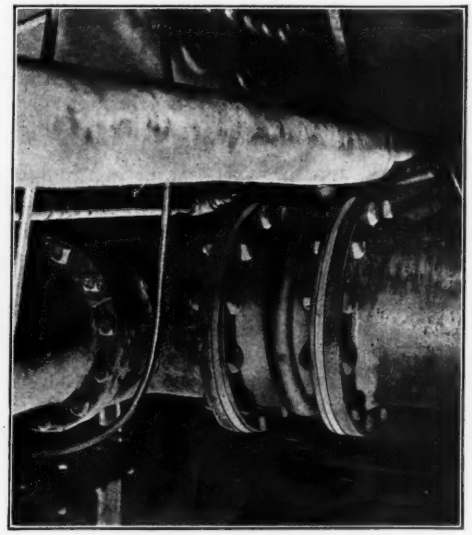


FIG. 8. MANY APPLICATIONS ARE FOUND FOR THE USE OF RUBBER EXPANSION JOINTS

Some rubber expansion joints have a thick-walled construction of solid rubber reinforced by heavy fabric and by steel rings to obtain strength for general service. The expansion is taken up by the arch of rubber and fabric at the middle. Joints of this type are regularly furnished in three different shapes for various purposes, and in a large range of sizes. The regular round, or spool type, joint is made in all standard pipe sizes from 3 in. to 72 in. Oval, or rectangular, joints are similar to the round joint and are made to suit requirements. Taper joints are made on special order only, to connect flanges at different diameters. Internal flanged joints can be supplied in either the round or the oval form when necessary. Steel retaining rings, split into halves, are furnished with external flanged joints, and retaining flanges with internal flanged joints. Flanges are furnished in standard pipe sizes, and are drilled according to standard bolt circles, unless otherwise ordered.

Rubber expansion joints of the plain type are designed for any kind of service on pipe lines where the pressure is not above atmospheric and on water lines up to a pressure of 25 lb. The plain spool type joint is reinforced so that it will withstand outside pressure sufficiently to be safely used under any degree of vacuum. The plain joint of any type is recommended for universal use under the conditions described, and for temperatures up to 180 deg. F. It may be subjected to slightly higher temperatures temporarily without any ill effects. Test pressures up to 450 lb. have been applied to high pressure joints of this type.

Tests of Vertical Uniflow Engine*

WITH VARIOUS PRESSURES, USING BOTH SATURATED AND SUPERHEATED STEAM, TEST SHOWS INTERESTING RESULTS. BY GEORGE H. BARRUS.

INTERESTING TESTS have been recently conducted by the writer on a four-cylinder, vertical uniflow engine, non-condensing, driving a 400-kw. a.c. Burke generator, direct connected, with loads ranging from one-quarter to full load, under various conditions, with saturated and superheated steam. The tests were conducted for the Great Western Laundry Co. of Chicago, purchaser of the engine, making use of the testing plant of the Ames Iron Works, Oswego, N. Y., where the engine was designed and built.

On this engine, the admission valves are double-beat poppets, lifted vertically by a horizontal camshaft, which is moved laterally by a horizontal centrifugal spring-resisted governor, thus varying the cutoff. The cylinders, together with the heads, are steam jacketed and are arranged in two pairs, with cranks 90 deg. apart, the two corresponding cranks of either pair being 180 deg. apart. Two cylinders are thus filled with steam from the source of supply at each quarter of a revolution. The total volume of these piston displacements is 0.71 cu. ft., that of the entire jacket spaces and steam chests is 8.2 cu. ft., and that of the throttle valve and piping from the cylinder flange to the stop valve on the steam drum, 2.0 cu. ft. Thus the amount withdrawn each time is only about one-twelfth of the jacket volume.

In this connection it was noticeable that the fluctuations of steam pressure at the throttle valve were extremely small; indeed, the cock on the steam gage at the throttle was kept wide open, and the gage pointer vibrated not more than its own width. The steam-pipe diagrams taken at the throttle valve were practically straight lines. The practical absence of pressure variation in the steam main contributes not only to steam economy but to structural advantages as well, for it makes the pipe itself secure with a minimum amount of anchorage; further, it enables the size of the pipe to be reduced to the smallest permissible diameter—in this case 5-in. extra heavy. The velocity of the steam in the pipe at the greatest load (15,214 lb. per hr., average) is estimated at 108 ft. per sec. (6480 ft. per min.).

Moving parts of the engine are shut in by a casing and no adjustment from the outside can be made, while it is in operation, except to vary the speed by tightening or loosening the governor spring. This construction admits of the efficient use of a pressure oiling system for the lubrication of the entire engine, no oil cups or grease cups being required.

For measuring the steam consumption, the apparatus consisted of a surface condenser of ample capacity, placed

*From a paper presented at the Spring Meeting of the A.S.M.E., at Milwaukee, Wis., May 18 to 21, 1925.

below the level of the engine and discharging by gravity into a pair of steel-plate weighing tanks, which were alternately filled and emptied. In conducting the tests, the methods recommended by the A. S. M. E. were substantially followed. Under each load the current from the generator was absorbed by a water rheostat, and the load was maintained constantly at the desired point by hand regulation at the switchboard or rheostat terminals. The loads selected (exclusive of direct-current exciter, using from 3 to 5 kw.) were 100, 200, 300, and 400 kw. Table I shows the dimensions of the engine.

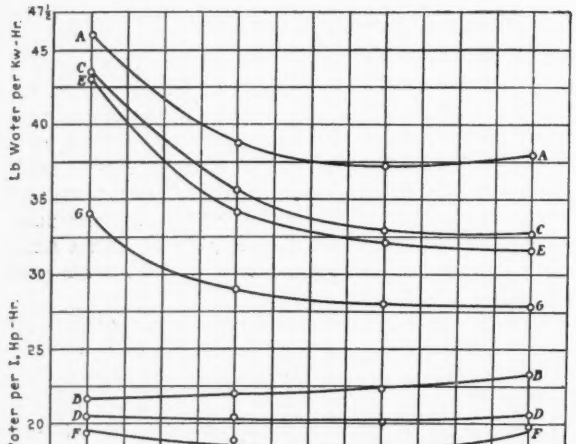


FIG. 1. CURVES SHOWING RESULTS OF TESTS ON UNIFLOW ENGINE

A and B: Saturated steam, 125 lb., 5 lb. back pressure, 22 per cent clearance. C and D: Saturated steam, 125 lb., atmospheric exhaust, 17 per cent clearance. G and H: Superheated steam, 150 lb., atmospheric exhaust, 17 per cent clearance.

TABLE I. DIMENSIONS OF UNIFLOW ENGINE TESTED

1. Number of cylinders	4
2. Diameter of each cylinder	14 in.
3. Diameter of each piston rod	2⅜ in.
4. Stroke of each piston	16 in.
5. Normal speed	300 r. p. m.
6. Piston speed in feet per minute at 300 r. p. m.	800 ft.
7. Clearance volume in per cent of piston displacement as calculated from drawing, first and second series	22 per cent
8. Clearance volume calculated for third and fourth series	17 per cent
9. Inside diameter of steam pipe	4.8 in.
10. Inside diameter of each of the two exhaust pipes	8 in.

There were four series of tests, each with the four loads specified.

On all the saturated steam tests, the steam was practically dry, a throttling calorimeter showing almost constantly a temperature of 277 deg. F. with 125 lb. pressure at the throttle valve, indicating a moisture content of less than one-half of one per cent. No correction was made for this.

Diagrams and kilowatt readings were taken simultaneously to determine the indicated horsepower, correcting for any departure from the even loads, which were the points at which the averages were continuously maintained. The error caused by taking diagrams with three-way cocks is practically offset by a corresponding error due to the reducing motion in use, which acts the opposite way; these errors may be disregarded.

Economy results of the various tests are shown graphically by points on Fig. 1. It is interesting to note the effect that superheating produced on the curve H of that series as compared with the corresponding curve F given with saturated steam; in the superheated-steam case the curve is substantially a straight line. The manner in which the steam is distributed in the cylinders by the use

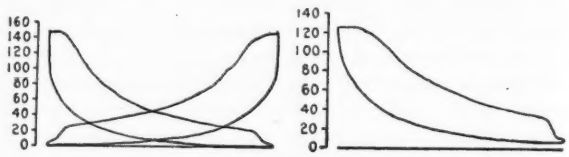


FIG. 2. INDICATOR DIAGRAMS TAKEN DURING TEST

of the uniflow principle and its attending valve mechanism and arrangement of cylinders may be seen by reference to the two indicator cards reproduced in Fig. 2, A and B.

In connection with the operation of the uniflow principle in this engine, the question of cylinder condensation comes to the front. Table II, showing the steam accounted for by the indicator diagrams in one of the series of tests with saturated steam, reveals excellent conditions regarding condensation and leakage.

TABLE II. STEAM ACCOUNTED FOR BY DIAGRAM ON FIRST SERIES OF TESTS WITH SATURATED STEAM

	Load in Kilowatts			
	100	200	300	400
1. Apparent cutoff, per cent.	4.1	8.0	11.2	16.9
2. Steam accounted for by diagrams per i. hp.-hr., lb.	13.72	16.96	17.49	18.2
3. Actual steam consumed per i. hp.-hr., lb.	20.6	20.4	20.1	20.7
4. Percentage accounted for.	66.6	83.1	87.0	88.0

AGAIN THIS year, Wembley, near London, Eng., will be the scene of a great educational exhibit, brought from the ends of the earth to show British resources. Exhibits are being revised and renewed by the home manufacturers and the colonies so that it will be, in effect, a new display. Manufacturers, engineering construction and machinery will have a prominent place, though arts and amusements will also be notable features. Housing, transport and communication will be given special attention in the Palace of Engineering. It will be a center where engineering progress can well be studied in compact, condensed form. The exhibition will be open, as last year, from May to November.

THE TONOPAH EXTENSION MINING CO. of Tonopah, Nev., has just completed the installation in a new power house building of two Bethlehem Diesel engines of 1300 kw. capacity each. Provision has also been made for the erection in the same building of a third unit of similar capacity.

Testing Steam Engines by Heat Balance Method

WATER RATE OF RECIPROCATING ENGINES EQUIPPED WITH JET CONDENSERS CAN BE DETERMINED IN A FEW MINUTES. BY EUGENE OGUR

ORDINARILY A STEAM prime mover is guaranteed by the builders to consume not more than a specified amount of steam per indicated horsepower or kilowatt-hour, provided the unit is operated at the rated load and speed, the steam pressure and superheat at the throttle and the vacuum at the exhaust are as specified, the valve and piston rings or gland packing are tight, the condensation not excessive and the load is evenly distributed between the cylinders.

Any change in the foregoing provisions will result in an increased steam consumption which will aggravate with time until it may be 50 per cent above the guaranteed amount. Some of the changes may be unavoidable under the operating conditions but those that are avoidable should be detected and remedied as they occur. How then may they be detected?

Fundamentally the steam consumption or water rate of a steam prime mover is a true indication of its economy. For this reason frequent determination of the water rate is the only means of detecting increased steam consumption which in the average plant is responsible for losses running into thousands of dollars per year. In the case of a steam turbine equipped with any kind of a condenser a flow meter at the throttle will yield satisfactory information, accurate within 1.5 to 2.0 per cent and in the case of any kind of a prime mover equipped with a surface condenser, a hot water meter in the condensate return line will yield reliable information. But the reciprocating engine equipped with a jet condenser presents a problem which engineers have been trying to simplify for years past.

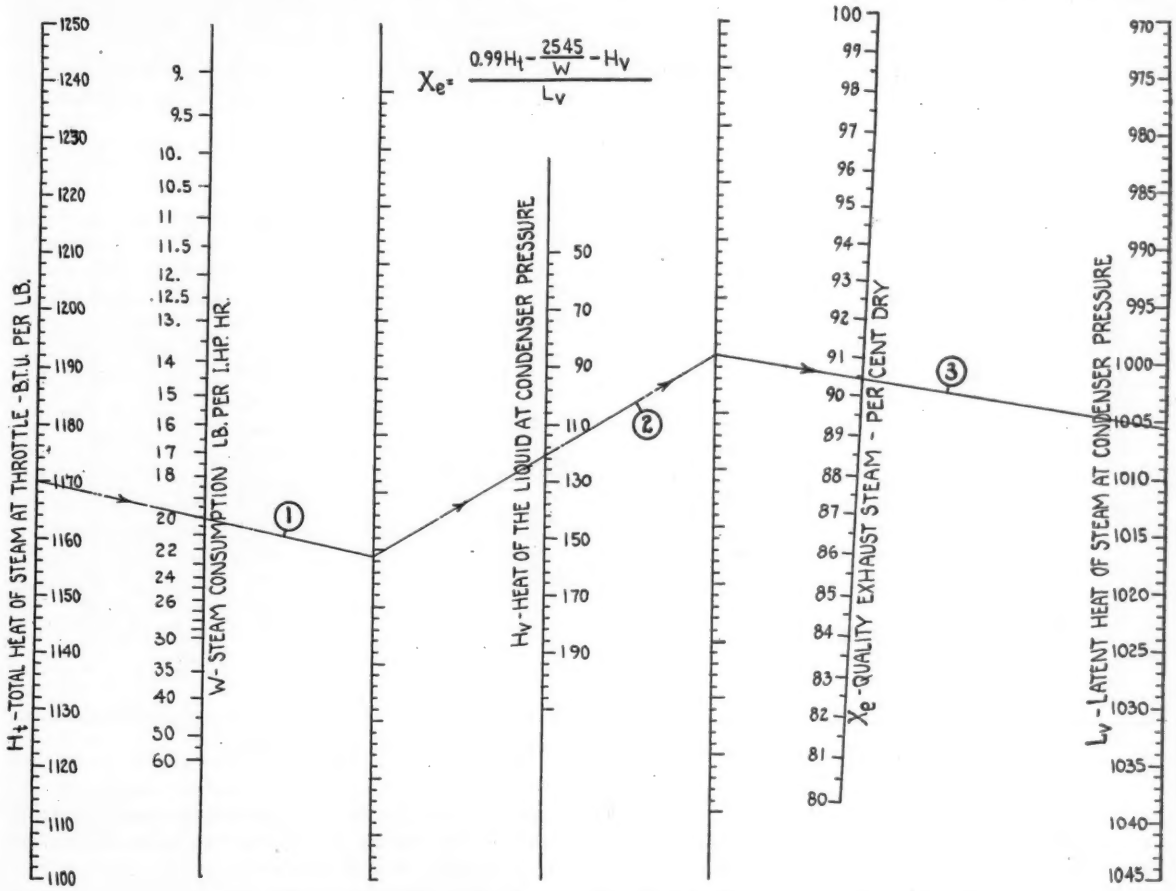

$X_e = \frac{0.99H_t - \frac{2545}{W} - H_v}{L_v}$
H_t - TOTAL HEAT OF STEAM AT THROTTLE - B.T.U. PER LB.
W - STEAM CONSUMPTION LB. PER I.H.P. HR.
H_v - HEAT OF THE LIQUID AT CONDENSER PRESSURE
X_e - QUALITY EXHAUST STEAM - PER CENT DRY
L_v - LATENT HEAT OF STEAM AT CONDENSER PRESSURE
1
2
3

FIG. 1. METHOD OF DETERMINING QUALITY OF EXHAUST STEAM IN A VACUUM

To date probably the most noted and perhaps unique method of solving this problem is that originated by J. P. Clayton. His method consists of transforming the indicator card into a logarithmic diagram. This method, first described to the A. S. M. E. in 1912, created considerable interest, but it is too technical and laborious for the practical engineer. Besides, the method does not account for loss due to leaky valves and pistons, except relatively. It is leakage behind the valves and pistons that is responsible for the increased steam consumption more than all other causes taken together.

The modern reciprocating engine, particularly that of the uniflow type, compares favorably in steam economy with a small turbine and, on account of its moderate speed, is better adapted for industrial plant service. Further-

more, on account of the difficulty of separating the cylinder lubricating oil from the exhaust steam, a reciprocating engine is almost invariably served by a jet condenser. Consequently the operator of an industrial power plant using this equipment cannot avail himself of such simple means of determining the steam consumption of his engines as a flow meter or hot water meter. The only means available to him is the official test prescribed by the A. S. M. E. Power Test Code, which consists of isolating the engine under test, and a boiler or battery of boilers supplying steam to the engine, from the rest of the system, weighing the amount of water fed into the boilers for a period of 8 to 10 hr., deducting various leaks between the weighing tanks and the throttle and dividing that by the indicated horsepower-hour or kilowatt-hour developed during the same period.

readings may be taken by any operating engineer and the results computed in less than 10 min. time. Furthermore, by means of a set of charts previously computed to cover the operating range of a given installation, the results may be obtained in less than 2 min. time.

To illustrate the application of the method, consider the installation of a Corliss engine equipped with a jet condenser and having the following specifications: Rated load, 1500 i.hp.; normal speed, 100 r.p.m.; steam pressure at throttle, 150 lb. gage; steam superheat at throttle, 90 deg. F.; vacuum at engine exhaust, 27.5 in. mercury (Bar. 30 in.); guaranteed economy at above operating conditions, 11.0 lb. steam per i.hp.-hr. To check the performance of the installation arrangements were made for a test. The first step was to provide means for measuring the condenser discharge. The installation of a weir in the condenser dis-

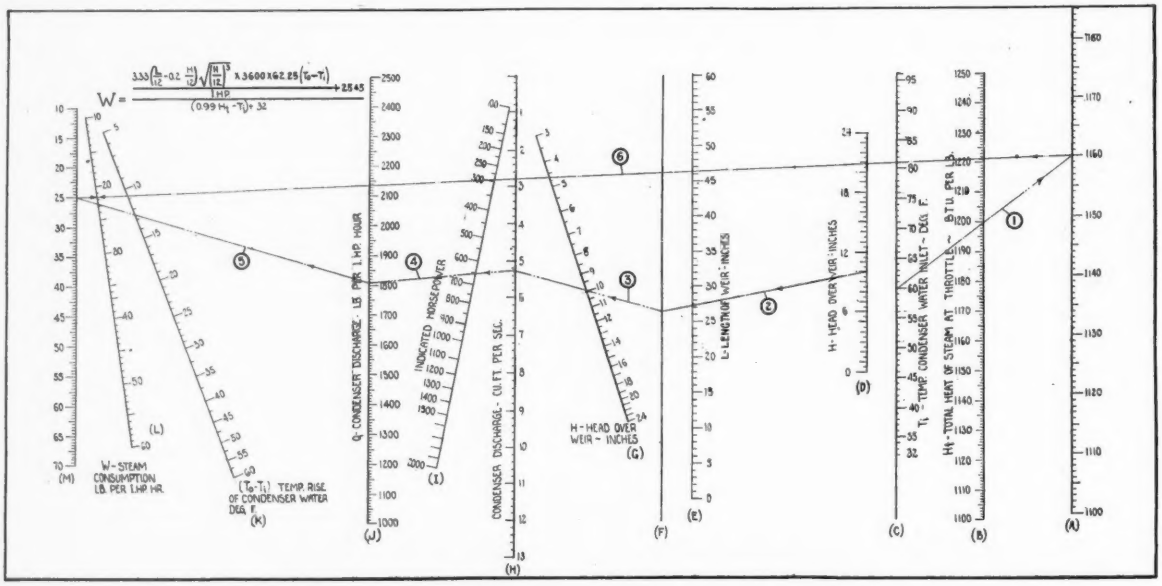

W = 3.33(h/12 - 0.2)√(h/12)³ × 3600 × 62.25(T₀ - T₁) / (0.99 H_t - T₁) + 32 / 1 HP + 2545
W - STEAM CONSUMPTION LB. PER I.HP. HR.
(T₀ - T₁) TEMP. RISE OF CONDENSER WATER DEG. F.
Q - CONDENSER DISCHARGE - LB. PER 1 HP HOUR
INDICATED HORSEPOWER
CONDENSER DISCHARGE - CU. FT. PER SEC.
H - HEAD OVER WEIR - INCHES
L - LENGTH OF WEIR - INCHES
H - HEAD OVER WEIR - INCHES
T₁ - TEMP. CONDENSER WATER INLET - DEG. F.
H_t - TOTAL HEAT OF STEAM AT THROTTLE - B.T.U. PER LB.

FIG. 2. METHOD OF DETERMINING WATER RATE OF PRIME MOVERS

Unfortunately, the complete isolation of a boiler and engine from the usual power house system is not a simple matter. Valves are never tight and in the case of a plant several years old the leakage between the test header and the rest of the system may exceed 35 per cent. It becomes necessary then, for reliable results, to blank off all the avenues of possible leakage, such as blowoff valves, division valves and cross-connecting valves. It is also advisable to step up the safety valves a few pounds, lest a slight increase in pressure will open the safety valve and void the entire test perhaps a few minutes before it is completed. Such a test is expensive, interferes with normal operation of the plant and at the best yields "test" performance which may or may not be duplicated in actual operation. It obviously cannot be carried out at such frequent intervals as are necessary to maintain the continuous economy of the unit.

Confronted with the necessity of ascertaining the economy of an installation of several reciprocating engines equipped with jet condensers, at frequent intervals, the writer, after considerable research, developed a method whereby the water rate of such installations may be determined from a single set of instantaneous readings. The charge well was found to be the simplest and most reliable method. The following readings were taken simultaneously, or as nearly so as practicable:

Steam pressure at throttle, lb. gage	148
Steam temperature throttle, deg. F	385
Vacuum at engine exhaust in. mercury corrected to 30 in. barometer	25.9
Speed, r.p.m.	100
Generator voltage	114
Output amp.	10500
Indicated hp.	1925
Head of water over crest of weir, in	13.5
Length of weir, ft	3.5
Temperature of condensing water, deg. F	43.0
Temperature of condenser discharge, deg. F	52.5

The fundamental formula developed is

$$W = \frac{Q\ (T_o - T_1) + 2545}{(0.99\ H_t - T_1) + 32}, \text{ where} \qquad (1)$$

W = Steam consumption per i.hp.-hr., lb. of steam
Q = Lb. of water discharged per i.hp.-hr., computed from weir measurements

H_t = B.t.u. per lb. of steam at the throttle, obtained from steam tables

T_i = Temperature of condensing water, deg. F.

T_o = Temperature of condenser discharge, deg. F.

The value (Q) may be determined by first computing the discharge in cubic feet per second by means of Francis' formula for a rectangular weir with complete end contraction:

$$C = 3.33\ (L - 0.2H)\ \sqrt{H^3}, \text{ where} \qquad (2)$$

C = Cu. ft. discharged per sec.

L = Length of weir in ft.

H = Head of water over crest of weir, ft.

It should be noted that this formula is only applicable to the type of weir used. Under different conditions, V-notch weirs or trapezoid weirs may be found more convenient. For complete information on various types of weirs and formulas applicable to them, see any Mechanical Engineers' Handbook, or the A. S. M. E. Power Test Code.

Substituting in formula (2), we get

$C = 3.33\ (3.5 - 0.2 \times 1.125)\ \sqrt{1.125^3} = 13.00$ cu. ft. per sec. The weight of water at the condenser discharge temperature, 52.5 deg. F. is 62.41 lb. per cu. ft. and the i.hp. is 1925. Hence the quantity of water discharged per i.hp.-hr. is $Q = 62.41 \times 13 \times 3600 \div 1925 = 1518$ lb. The B.t.u. per lb. of steam at the throttle, H_t, is equal to 1207, from steam tables.

Substituting in formula (1), we get

$$W = \frac{1518 \times (52.5 - 43) + 2545}{(0.99 \times 1207 - 43) + 32} = 14.32 \text{ lb.}$$

per i.hp.-hr. This showed a steam consumption of 3.32 i.hp.-hr. in excess of the guarantee.

If it is inconvenient to take indicator cards, the kilowatt-hours developed shown by the switchboard instruments may be used for computing the water rate of the unit. The formula to be used in that case is

$$W^1 = \frac{Q^1\ (T_o - T_i) + \frac{3415}{\text{Eff.}}}{(0.99H_t - T_i) + 32}, \text{ where} \qquad (3)$$

W^1 = Steam consumption per kw-hr.

Q^1 = Condenser discharge, lb. per kw-hr.

Eff. = Combined electrical and mechanical efficiency.

3415 = Mechanical equivalent of a kilowatt-hour.

Other symbols as before

The combined efficiency in this case figures out

$$\frac{114 \times 10500}{746 \times 1925} \times 100 = 83.3 \text{ per cent.}$$

Reference to the engine and generator manufacturers' guarantees indicated that the combined efficiency at that load was guaranteed to be 83.0 per cent. The amount of water discharged by the condenser per kilowatt-hour, Q^1, is

$$\frac{62.41 \times 13 \times 3600}{114 \times 10500} \times 1000 = 2515 \text{ lb. per kw-hr.}$$

Substituting in formula (3), we get W^1, the steam consumption per kw-hr., equals

$$\frac{2515 \times (52.5 - 43) + \frac{3415}{0.83}}{(0.99 \times 1207 - 43) + 32} = 23.6 \text{ lb. per kw-hr.}$$

The determination of the steam economy is usually the prime object of making such a test. But having secured the required measurements, it is a simple matter to carry out a few additional computations yielding information which will throw some light on whether or not the unit is being operated properly and what condition the valves and piston rings are in. Thus, the load at which the unit is operated is found by the formula

$$\frac{\text{Oper. i.hp.}}{\text{Rated i.hp.}} \times 100 = \text{per cent operating load} \qquad (4)$$

The amount of condensing water per pound of steam is found by the formula

$$\frac{Q - W}{W}, \text{ or } \frac{Q^1 - W^1}{W^1} \qquad (5)$$

The dryness of the exhaust steam, which is an indication of the tightness of the valves and piston rings, may be found by the formula

$$X = \frac{0.99\ H_t - \frac{2545}{W} - h_v}{L_v}, \text{ where} \qquad (6)$$

X = Dryness of exhaust steam

H_v = Heat of the liquid at the absolute pressure corresponding to the operating vacuum

L_v = Heat of vaporization at the absolute pressure corresponding to the operating vacuum

Other terms as before.

Substituting in (4), (5) and (6), we get:

Per cent load at which the unit is operated

$$\frac{1925}{1500} \times 100 = 128.0 \text{ per cent or 28 per cent overload;}$$

Pounds of condensing water per pound of steam

$$\frac{1518 - 14.32}{14.32} = 104 \text{ lb.;}$$

Dryness of exhaust steam

$$X = \frac{0.99 \times 1207 - \frac{2545}{14.32} - 94}{1201} = 0.904 \text{ or } 90.4 \text{ per cent.}$$

Figure 1 is an alinement chart which may be used in determining the quality of exhaust steam in a vacuum. There are practically no data available on the subject since no means have as yet been devised for measuring it. This chart is so easy to read that a detailed explanation is not deemed necessary.

Results of Test Show Point of Trouble

1. The unit was being operated at 28 per cent overload.

2. The steam consumption was 30 per cent higher than the guaranteed amount. This may be partly accounted for by the following deviations from specified conditions; 28 per cent overload, 2 lb. deficiency in steam pressure, 70 deg. F. deficiency in superheat and 1.6 in. deficiency in vacuum. It may be noted that the recommendations for overhauling the valves and piston rings were carried out and that subsequent tests showed the steam consumption reduced almost to the guaranteed amount. This also permitted a reduction in the amount of condensing water per pound of steam from 104 to about 30 lb. with the result of 1 in. increase in vacuum and 40 per cent saving in the cost of pumping the condensing water.

3. The ratio of the amount of condensing water to the steam was seven times the theoretical amount required and should have been 65 per cent less, thereby reducing the cost of pumping the condensing water and getting rid of the air introduced into the condenser with the water.

4. The dryness of the exhaust steam, 90.4 per cent, was too high. For economical operation in a unit of this size and type, the quality should not exceed 85 per cent. The high quality of the exhaust steam indicated that a considerable amount of steam was leaking behind the valves and piston rings and, without doing any work, increased the heat rejected to the condenser. This leakage more than any other factor accounted for the increased steam consumption and warranted the immediate overhauling of the valves and piston rings of the unit.

Water Rate Easily Found by Means of Charts

As stated before, the computation may be appreciably simplified and the results obtained in less than 2 min. time from a set of charts plotted to cover the operating range of a given installation. Figure 2 is an alinement chart which is designed to show steam consumption under all average operating conditions, as outlined in this article. As shown by the formula in the upper lefthand corner of the chart, calculations have been based on what may generally be considered an average temperature of water discharged from a condenser — 73 deg. F. This is the reason for the value (62.25), which is the weight of a cubic foot of water at this temperature. In the problem previously worked out, the weight of a cubic foot of water is 62.41 lb., since the water temperature was unusually low, the test having been made in very cold weather. The conditions of the problem illustrated by the chart are somewhat different from those in the previous discussion in order to show that the method is practical for any condition. In this problem we have:

H_t = Total heat of steam at throttle = 1200 B.t.u. . . . . *B*

T_1 = Temp. of condenser water inlet = 60 deg. F. . . . . *C*

T_o = Temp. of condenser water outlet = 72.75 deg F.

H = Head of water over weir, in. = 10 . . . . . *D*

L = Length of weir, in. = 27.2 . . . . . *E*

C = Condenser discharge, cu. ft. per sec. = 5.2 . . . . . *H*

I.hp. = Indicated horsepower = 650 . . . . . *I*

Q = Condenser discharge, lb. per i.hp.-hr. = 1800 . . . . *J*

$T_o - T_1$ = Temp. rise of condenser water, deg. F. = 12.75 . . . . . *K*

W = Steam consumption, lb. per i.hp.-hr. = 21.98 . . . . *L*

In this problem the values in vertical lines *C* and *B* are connected by line (1), which is extended through to vertical line *A*. Next, values in *D* and *E* are connected by line (2), which is extended through to reference line *F*. From here, line (3) is run to the same value in *G*, as already shown in *D* and extended through to vertical line *H*. From here line (4) touches the value in *I* and is extended to *J*. From *J*, line (5) touches *K* and is extended through to *M*, no attention being paid to where it crosses *L*. The final step is to draw a line (6) from *A* to *M*. The point where this line crosses *L* will give the ultimate answer in terms of pounds of steam consumption per indicated horsepower hour.

By means of the method outlined in this article a great number of tests have been conducted when varying the load, superheat and vacuum over a wide range and results have proven the simplicity, cheapness, sensitivity, and above all, correctness of the method. It especially offers great opportunities of saving to industrial plant owners for it makes practicable the determination of the water rate of engines at frequent intervals at no extra cost. Operators will find it advantageous to provide a column in the daily log sheet, marked "Head of water over crest of weir" and have the engineer note that item along with the other usual daily records. It is then an easy matter for the power house clerk to figure out the steam consumption and quality of the exhaust steam hourly and average them up for each shift.

(Editor's note: The author of this article has given us a mathematical proof of the formulas he has developed which will be supplied to readers who are interested.)

Cost of Diesel Engine Operation

Summary of Data on Production Details and Costs Obtained From Users of Diesel Engines

RECENTLY THE prime movers' committee of the National Electric Light Association has reported on the present-day oil engine practice. Early in 1924 questionnaires were mailed out to Diesel engine users, requesting information regarding installation, operating and maintenance practice, also production details and costs.

TABLE I. CHARACTERISTICS OF PLANTS AND MAINTENANCE HISTORY

Item	Unit	Plant Number 1	2	3	4
Total plant capacity	h.p.	6500	9000	1875	1000
Number units, 2-cycle	....	4	6	.....	.....
Number units, 4-cycle	....	.....	.....	6	2
Size of units	h.p	2-2000	2-2000	5-225	2-240
	h.p	2-1250	4-1250	(1-750)	1-320
Age of engines	Yr	2	2 to 4	5 to 20	2 to 7
Manufacturer	....	Nordberg	Nordberg	(1) Busch (Mcl. S.)	Busch
Horizontal or vertical	....	Vert	Vert	Vert	Vert
Class of service	....	Mine Power	Mine Power	Central Station	Central Station
Necessity for overhauls	....	General 12-15 Mo	General 12-15 Mo.	1 to 3 years	After 6 yr. Service
Life of main bearings	....	Not yet determined	Not yet determined	4 to 5 years	None renewed
Life of cylinder heads	....	C.I. 4000 hr C.S. not yet determined	C.I. 4000 hr. C.S. not yet determined	Indefinite	5 years
Life of liners	....	20,000 to 24,000 hr	20,000 to 24,000 hr	Rebored 3 years	5 years
Life of pistons	....	Not yet determined	Not yet determined	*Indefinite	5 years
Labor cost, hr. per man day	$	.....	.....	4.36	4.40
Fuel consumption per kw-hr.	lb	0.703	0.752	0.896	0.75
Engine hours per gal	Lub	3.33	3.70	3.16	.....

*When liners are bored, pistons are held for future use in new liners. Small engines now in stand-by service.

This information, as obtained from four plants, is shown in the accompanying tables. Table I shows the characteristics of the plants and their maintenance history. It is interesting to note that the plant capacities range from 1000 hp. to 9000 hp. and that the range in unit sizes is from 225 hp. to 2000 hp. The period between successive major repairs does not seem to be well established within the present number of years of operation of these engines. Two of these stations report a labor cost average of $4.38 per man day. Fuel consumption ranges from 0.703 lb. per kw-hr. to 0.896 lb. per kw-hr., the average being 0.775 lb. Three plants reporting on lubrication agree quite closely on the engine hours produced per gallon of lubricant.

In Table II are shown operating data and costs. Here it is interesting to note that the load factors ranged from 19.5 to 52 per cent, the arithmetical average being 39.1

per cent. For the plant reporting the highest load factor the B.t.u. per kilowatt-hour output was 12,970 and the fuel cost per kilowatt-hour output was 0.472 cents. The average B.t.u. per kilowatt-hour was 14,496 and the average fuel cost per kilowatt-hour was 0.496 cents. The total production cost in cents per kilowatt-hour ranged from 0.745 for the plant with the highest load factor to 1.904 for the plant with the lowest load factor.

TABLE II. DIESEL PLANT OPERATING DATA AND OPERATING COSTS

Item	Unit	Plant Number			
		1	2	3	4
Total plant capacity	kw.	3,700	5,000	1,315	720
Annual station output	M kw-hr.	18,465.72	20,700.5	2,246.68	2,130.54
Average daily output	Mkw-hr.	50 0	56 7	0 16	5 84
Station load factor	%	52	42	19 5	34
Peak load	kw.	3200	3500	949	625
Peak load factor	%	.....	.....	27 0	.....
Generator load factor	%	91	78	72 2	86
Fuel oil used	M gal.	1,732.0	2,020.0	257 47	215 .8
Specific gravity of oil used	°Be.	14–15	14–15	32.5 & 15 7°	24–26
Fuel oil B.t.u. per lb.	B.t.u.	18,450	18,450	18,650	19,250
Avg. fuel used per kw-hr. output	lb.	0 703	0 752	0 896	0 75
Avg. B.t.u. per kw-hr. output	B.t.u.	12,970	13,875	16,688	14,450
Fuel cost per kw-hr. output	Mills	4 72	6 72	4 55	4 37
Labor cost total (not including maintenance)	$	18,801.06	19,687.41	17,025.08	3,547.59
Labor cost per kw-hr. output	Mills	1 02	0 95	7 58	1 665
Lubricants used	Gal.	6,099	7,679	3,757	3,730
Lubricants used per engine hour	Gal.	0 30	0 27	0 317	.....
Cost of lubricants per kw-hr. output	Mills	0 16	0 25	0 858	0 97
Maintenance cost—total, including labor	$	15,141.90	18,879.49	11,035.63**	8,567.34
Maintenance cost per kw-hr. output	Mills	0 82	0 91	4 92	4 01
Miscellaneous cost—total	$	13,295.32***	15,111.37***	2,528.29	1,513.41
Miscellaneous cost per kw-hr. output	Mills	0 72	0 73	1 13	0 71
Production cost—total	$	137,569.61	187,314.15	42,732.86	25,775.87
Production cost per kw-hr. output	Mills	7 45	9 05	19 04	12 10

*32.5 deg. distillate used in 225-hp. engines. 15.7 deg. fuel oil in 750-hp. engine.
**Maintenance high on account of corrosive cooling water.
***Miscellaneous costs include water, general plant repairs and supplies, insurance, department overhead, but no interest or depreciation.

Diesel engines have recently replaced steam drives at a plant at Neodesha, Kan. After 10 mo. of Diesel operation, the following comparisons have been made: cost per kilowatt-hour by steam, 4.69 cents and by Diesel engine, 1.26 cents. This shows a saving in the cost per kilowatt-hour by the Diesel plant of 73.1 per cent. The total saving in the 10 mo. operation of the Diesel plant was $18,624.27 or 56.8 per cent. The load has increased 59.6 per cent since the oil installation was made.

Economy of the Steam Jet Air Pump

CONVENIENCE OF INSTALLATION OFTEN INFLUENCES AUXILIARY SELECTION. BY H. E. CARLETON*

SOME ADVANTAGES of the steam jet air pump over mechanical types of air pump are: the first cost of the steam jet air pump is lower than any other air pump, it requires no special foundations, no driving motor, and may be mounted on either side of the condenser, in a space too small for other kinds of air pumps. With inter- and after-condensers it is entirely self-contained. It is easy to operate and may be started or stopped by merely turning steam on or off.

In calculating the comparative economies of steam jet and mechanical air pumps there are so many factors to be considered, such as the method of heating the boiler feed water, the state of repair of the mechanical air pump and the amount of air leakage into the condenser, that no general conclusion can be drawn. A few examples, however, of how the different pumps have shown up in practice can be given.

*Engineer, Wheeler Condenser & Eng. Co.

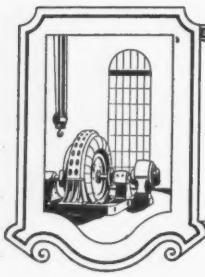
One opportunity to compare the economy of a hydraulic pump with a steam jet air pump was recently presented at a central station. A steam jet air pump using 1150 lb. of steam per hr. replaced two hydraulic air pumps each driven by a 50-hp. motor, and maintained 0.2 in. better vacuum at 29 in. If it is assumed that the motors driving the hydraulic pumps had an efficiency of 90 per cent and that the water rate of the main unit is 14 lb. of steam per kw-hr., a total of 1170 lb. of steam per hr. is required to operate the driving motors, neglecting transformer losses. When it is considered that the heat in the steam used to operate the steam jet air pump is all returned to the condensate, whereas the steam used to generate the 100 hp. used by the motors is condensed in the condenser, the difference between the two types of pumps is marked. Assuming the plant to operate 6000 hr. a year and the boilers to generate 9 lb. of steam per lb. of coal costing $6 per ton, the steam jet shows a saving of $2460 a year over the motor driven unit—more than the entire cost of the steam jet.

STEAM JET PUMP REPLACES MECHANICAL PUMP

If a steam driven mechanical air pump is used, the advantage of a steam jet air pump is even greater. Units No. 1 and 3 at a central station were originally each served by a 125-hp. hydraulic air pump driven by a 125-hp. turbine having a water rate at 32.8 lb. of steam per hp. hr. or 4100 lb. of steam per hr. for each air pump. These two air pumps were replaced by one steam jet air pump, which serves both condensers at the same time, with a total steam consumption of 2400 lb. of steam per hr. or 1200 lb. of steam per hr. per condenser.

Where stage bleeding is employed the computations are somewhat more involved. Recently a steam jet air pump requiring 1200 lb. steam per hr. was compared with a hydraulic air pump requiring 55 b.hp. Taking into account the motor efficiency, this meant 50 kw. supplied by the main unit at a water rate of 10 lb. per kw-hr., or only 500 lb. of steam per hr. While the heat from the steam jet is all recovered by the feed water, and the equivalent heat required by the hydraulic pump is unrecoverable, if the 1200 lb. of steam required by the jet were put through the main turbine, it would generate 120 kw. By bleeding 1200 lb. of steam from a low pressure stage of the turbine, the feed water could be heated to the same temperature as with the steam from the jet air pump. As the water rate was 15 lb. per kw. at the lowest point of bleeding, this bled steam would generate 80 kw. The hydraulic pump would then be charged with $120 - 80 = 40$ kw., the loss in kw. due to bleeding 1200 lb. steam, plus 50 kw. actually required by the motor driving the hydraulic pump = 90 kw. total. That is, the hydraulic air pump was charged with 900 lb. of steam or 300 lb. less than the steam jet air pump.

There was, however, a temperature rise in the hurling water of the hydraulic pump of 2 deg. F. As the hydraulic pump used 1800 g.p.m., multiplying 1800 g.p.m. by 8.3 lb. per gal. $\times$ 2 deg. F., this meant 29,800 B.t.u. per min., which is equivalent to 1790 lb. of steam per hr. sent to the river by the circulating water in the re-cooling tank, or a saving of 1490 lb. of steam in favor of the steam jet. In a plant where the boiler feed make-up water is evaporated, this 1490 lb. of steam taken out of the system every hour would also require in a double effect evaporator, about 800 lb. of steam per hr.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Types and Characteristics of D. C. Motors

A Study of Their Speed, Starting Torque and Overload Characteristics. By Charles G. Green*

MANY advantages offered by electric motors over all other methods of drive are responsible for their wide adoption in every industry requiring power. There is, perhaps, no piece of apparatus which cannot be operated more efficiently by the electric motor than by any other means.

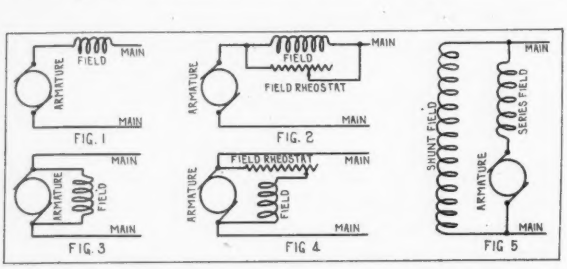


FIG. 1. CONNECTIONS OF SERIES MOTOR

FIG. 2. CONNECTION OF FIELD SHUNT ON SERIES MOTOR FOR SPEED CONTROL

FIG. 3. CONNECTIONS OF SHUNT MOTOR

FIG. 4. CONNECTION OF FIELD RHEOSTAT ON SHUNT MOTOR TO VARY SPEED

FIG. 5. CONNECTIONS OF CUMULATIVE COMPOUND MOTOR

In fact some companies and concerns have found it decidedly to their advantage to scrap the expensive systems of line shafting and belting and substitute the direct motor drive.

Advantages of motor drive over other methods may be summed up as follows: 1. Wide range of speed. 2. Compactness. 3. Portability. 4. Rotative rather than reciprocating motion. 5. No shafting or belts. 6. Economy—due to centralization of power and large prime movers resulting in fewer attendants, lower first cost, and increase in efficiency. 7. Constant speed,—requires no complicated governing devices. 8. Ability to stand overloads. 9. Little or no noise. 10. Little or no heat. 11. No steam pipes. 12. Ease in starting. 13. No operating expense when not running. 14. Little or no fire risk. 15. Readiness after being idle any length of time. 16. Simplicity. 17. Long life.

Successful operation of a motor depends on intelligent selection, maintenance and application. No matter how good its design, how sturdy its construction, or how much is paid for it, we cannot hope to get the best of service from it, if applied to work for which it is not suitable.

Its general class, such as shunt, series, compound, its characteristics, also the degree of enclosure and its mechanical structure must be taken into consideration in making a satisfactory and economical selection. Almost any plant, industrial or otherwise, operating on direct or alternating current, whichever is better available, and with motors properly selected, installed and operated, will give maximum efficiency with moderate first cost and a minimum of upkeep expense.

When two kinds of current are available, in making our choice we must take into consideration the distance which the electrical energy must be transmitted and the kind of work or nature of work to be done. Some consideration is given in this article to the characteristics of the main classes of d.c. motors, which are series, shunt, and compound, also why they have these characteristics. These classes can be subdivided according to construction details, into open type, closed type, and semi-closed type. Also motors in each class may differ mechanically from other motors in the same class due to their design for certain kinds of work.

Speed and Torque Characteristics of D.C. Motors

In the series motor, the field being in series with the armature, all the armature current must flow through the field. If the current through the armature is large, due to the motor carrying a heavy load, current in the field is also heavy, causing a strong or more dense field flux and the motor slows down with this increase of field strength. It can be seen from this that the speed of a series motor varies inversely with the load, or, as the load increases, the speed decreases and, as the load decreases, the speed increases. If load be thrown off entirely, the motor will reach a dangerously high speed. As the armature current is high when starting any motor, it makes the field of the series motor correspondingly strong, which produces a good starting torque. Also the series motor, due to the field carrying all of the armature current, will carry heavy overloads but with a corresponding decrease in speed.

One way of regulating the speed of a series motor is to put a variable cast grid resistance in parallel with the field, so that the current can be allowed to flow through the field, making it strong, or can be shunted around the field through the resistance grid, making the field weaker and thus letting the speed increase. Another way is to put a variable resistance in series with the armature and field. Speed regulation of a series motor is, however, poor at the best.

In a shunt motor the field is connected directly across the line, has impressed on it a constant voltage and, therefore, a constant current will flow in the windings of the

*Instructor in Motor Department, Coyne Electrical School.

field. It would seem, then, that there would be almost a constant flux between poles of opposite polarity at all times. But, as explained in Jan. 1 issue, 1925, the armature reaction has a demagnetizing effect on the field, which reaction is least when the motor is carrying no load. Therefore, a shunt motor has a stronger field when it is running idle, which has a tendency to hold the speed down. For this reason the shunt motor will not speed up to a dangerous degree, if the load falls to zero. When load is thrown on a shunt motor, it is natural to suppose that it would slow down and so it does, but not as much as might be expected. When the speed drops even a little, the counter e.m.f. is decreased. It then neutralizes less of the impressed e.m.f. and the difference between these voltages forces more current through the armature, giving it enough power to carry its load. The increased current through the armature also increases the armature reaction, which in turn neutralizes part of the field strength, so that the motor does not have to slow down so much to decrease the counter e.m.f. We can see by the foregoing that the speed of the shunt motor will be almost constant. The speed variation of a well-designed shunt motor should not be more than 5 per cent from no load to full load.

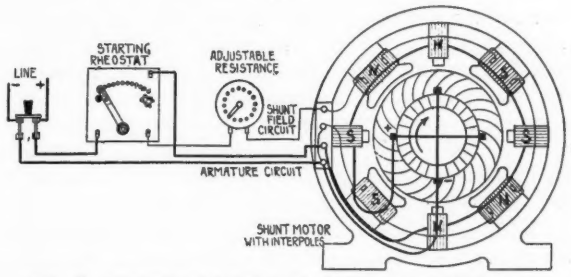


FIG. 6. PROPER RELATIVE POLARITY OF INTERPOLES

Due to the armature current in a motor being heavy at starting, the armature reaction is also strong at starting. It is so strong that it will have a tendency to neutralize part of the field flux, giving the shunt motor a weak starting torque and, if a heavy overload be connected to a shunt motor thus increasing the amount of current necessary to start it rotating, the armature reaction may become so great that it will almost entirely neutralize the field flux and the motor will not start. It can be seen then that the shunt motor will not start under too much overloads.

Speed of a shunt motor can be regulated with a fair degree of accuracy over a limited range by inserting a variable resistance, called the field rheostat, in series with the shunt field. By increasing the resistance, less current will flow through the field windings, so that the field will have a weaker magnetization or less lines of force. The armature conductors will then be cutting less lines of force and a correspondingly lower counter e.m.f. will be generated. The counter e.m.f. will then neutralize less of the impressed e.m.f. and more current will be forced through the armature, which will speed it up until it is generating the required counter e.m.f. By reducing resistance in the rheostat, an action opposite to the one just explained will take place. For the shunt motor, then, we see that it has a poor starting torque and a good speed regulation.

Compound motors, where the series and shunt fields are connected so that the flux produced by one is added to the flux produced by the other, are said to be cumulative compound. As stated before, the series motor produces a high starting torque and the shunt motor a low starting torque. A combination of the two, then, should have a fair starting torque and the compound motor has this. The series motor has poor speed regulation and the shunt motor good speed regulation. Then, as before, with the compound motor, having the characteristics of both series and shunt motor, the speed regulation will be fair. The series motor speed varies inversely over a wide range with the load. The shunt has almost constant speed. Then the combination which makes up the compound motor will have a slightly varying speed which varies inversely with the load.

A summary of the foregoing characteristics may simplify the picking out of various peculiarities more readily.

Series Motor

1. Speed varies inversely with load, continually.
2. High starting torque.
3. Carries heavy overloads for short intervals up to the point where the windings would be damaged.
4. Used where heavy loads must be started.
5. Speed regulation not good.
6. Reversed by reversing armature or field leads.

Shunt Motor

1. Almost constant speed up to full load.
2. Weak starting torque.
3. Liable to stop if overloaded beyond about 150 per cent rating.
4. Good speed regulation by shunt field rheostat.
5. Reversed by reversing armature or field leads.

Compound Cumulative

1. Speed varies slightly, inversely with load.
2. Fair starting torque, due to the series winding.
3. Can carry some overload up to point of overheating.
4. Speed regulation fair, not as good as shunt.
5. Reversed by reversing armature or field leads, best done by reversing armature leads.

In motors having commutating fields, or as commonly called interpoles, the interpole winding is generally connected at the factory in series with the armature and the two leads that are brought out are called armature leads. But in this case there really is one armature and one commutating field lead, the other two being connected inside. In this case, when reversing the so-called armature leads it does reverse the current through both the armature and commutating fields, which it should do. But it is always safer to notice the connections to make sure that by reversing armature current, the current through the commutating field also reverses, as the current, if reversed in one must be reversed in the other, so that the interpoles will always bear the same relation in regard to polarity with the main poles, which is that the interpoles must be of the same polarity as the main poles preceding them, or, in other words, the same polarity as the main poles next to them in the opposite direction to rotation.

Roger W. Babson, nationally known statistician and financial expert, says that "while the securities of light and power companies have been going up, the price of the commodity itself has been going down. The cost of electric power decreases per unit as the amount used increases. Electricity for light and power is being bought for less today than in any time in its history, and even lower prices will be introduced in many communities during 1925."

Automatic Control for Boiler Feed Pumps

Boiler Feed Pump Installation at New Peoria Station Is Provided With New Automatic Control. By L. W. Smith and W. C. Plumer

AN INTERESTING development in control equipment for electrically driven boiler feed pumps is seen in the installation being made at the new Peoria Station of the Illinois Electric Power Co. This station, which will have an ultimate capacity of 125,000 kv.a., is being constructed for an initial installation of 50,000 kv.a. and will use pulverized coal as fuel. It has a number of unusual features, among which the boiler feed pump installation is of particular interest.

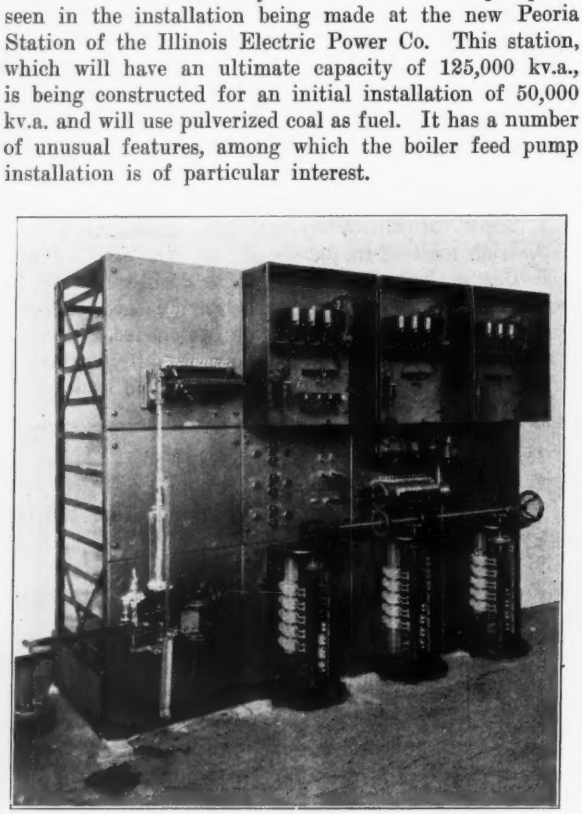


FIG. 1. VIEW OF CONTROL APPARATUS WITH COVERS REMOVED

There are three centrifugal type feed pumps, each driven by a 300-hp., 1800-r.p.m., 2300-v., 3-phase, 60-cycle, slip ring induction motor. The control for these pumps was designed to meet the following conditions:

(1) Automatic control of any combination of one to three pumps from one pressure regulator through a range of 85 to 100 normal speed with 13 running points; all motors to operate at approximately the same speed.

(2) Provision for remote hand control of the three pumps without the pressure regulator.

(3) Emergency hand operation without the pressure regulator.

The primary control of each motor consists of a Type K-35, General Electric T. P. S. T., 7500-v., 400-amp., solenoid operated, oil circuit breaker with inverse time limit overload relays and current transformers mounted on a removable truck forming part of the 2300-v. station auxiliary bus structure. The pull button control switches or stations with indicating lamps for these breakers are mounted on the master control panel described below.

The secondary control of the motors consists of a control board made up of four vertical slate sections as shown in Fig. 1. On each of three of these sections is mounted a T-708 motor-operated, 13-point drum controller, all being driven from a common shaft by a pilot motor. The controllers regulate the speed of the slip ring motors. A triple-pole contactor is provided for acceleration, and a current limit relay controls the closing of this contactor. The fourth section or master control panel has a Ruggles-Klingemann pressure regulator which actuates a C-429A master switch and three control stations for the primary oil circuit breakers. In addition to the master control panel, there is one twin pull button station mounted remote from the panel for operating the pilot motor driving the three drum controllers when the pressure regulator is not used, and three Type H, 1½-kv.a. 2200/220-v. control circuit transformers.

To start any one of the pump motors, the operator closes the corresponding line circuit breaker from the control button on the master control panel of the secondary board. The closing of the oil circuit breaker throws the motor on the line with resistance in the secondary circuit. As soon as the oil circuit breaker closes, the current and potential transformers energize the current limit accelerating relay which, in turn, controls the closing of the accelerating contactor, cutting out a small amount of resistance and bringing the motor up to its lowest running speed or to a speed corresponding to the setting of the drum controllers. This current limit relay is so set that the contactors cannot close until the line current has dropped to normal full load current of the motor.

With the S. P. D. T. lever switch in the control circuit thrown to the automatic position, the speed of the pump motors is controlled automatically from the steam pressure regulator. For example, referring to Fig. 2, let it be supposed that the Ruggles-Klingemann regulator moves the C 429A master switch to a point where the cylinder makes contact with Finger No. 65. This puts positive voltage on Finger No. 65 of the CC (control cylinder) master switch which will make contact on one side or the other of the insulated section. If this contact is so made as to energize Finger No. 74, the coil of contactor F is energized and the contactor held closed until the master switch has so moved that Finger No. 65 comes to the insulated section. Closing of this contactor energizes the pilot motor. This drives the T-708 drum controllers and cuts out resistance in the secondary of the slip ring motors, and also drives the small master switch which limits the travel of the controllers. If, on the other hand, the contact No. 65 is so made as to energize Finger No. 60, Contactor S will close and run the pilot motor and drum controller in the opposite direction until Finger No. 65 hits the insulated section.

As all three drum controllers are driven from one pilot motor, they all move regardless of whether all slip ring motors are running or not and, if the motors are all running, they are at approximately the same speed, thus keeping the amount of feed water supplied to the boilers the same throughout the system.

For remote hand control without the pressure regulator, the S. P. D. T. switch is thrown to the hand position. This puts positive power on one side of the pull button station which is mounted remote from the panel. If the operator wants more speed on his pump motors, he pulls the fast button. This energizes the fast contactor which is so held

in through a segment on one of the T-108 controllers that the controllers will run to the next definite operating point. Or, if he wishes to slow down the motor, he pulls the slow button which closes the slow contactor, moving the drum controller in the opposite direction.

Emergency hand control is obtained by means of a hand wheel mounted on the driving shaft of the T-108 controllers. This allows control in case of loss of power for the pilot motor, and allows hand manipulation for purposes of inspection, repairs, etc.

The motors are not provided with undervoltage release; however, if any undervoltage of approximately 50 or lower occurs, the triple pole contactors will drop out, inserting a small block of resistance in the secondary of the motors.

Electric Auxiliary Systems

A.C. Versus D.C. for Auxiliaries, Switches and Reactors

IN THE APRIL 15 issue, an abstract of a paper on the subject of Electric Power Systems for Auxiliaries delivered before the Schenectady section of the American Institute of Electrical Engineers by J. W. Dodge, the relative advantages of various systems for supplying electric power to auxiliaries were brought out and brief reference was made to the use of direct current for driving auxiliaries. In this article which is a continuation of Mr. Dodge's paper, the relative advantages of a.c. and d.c. power and the subject of switches and reactors are considered.

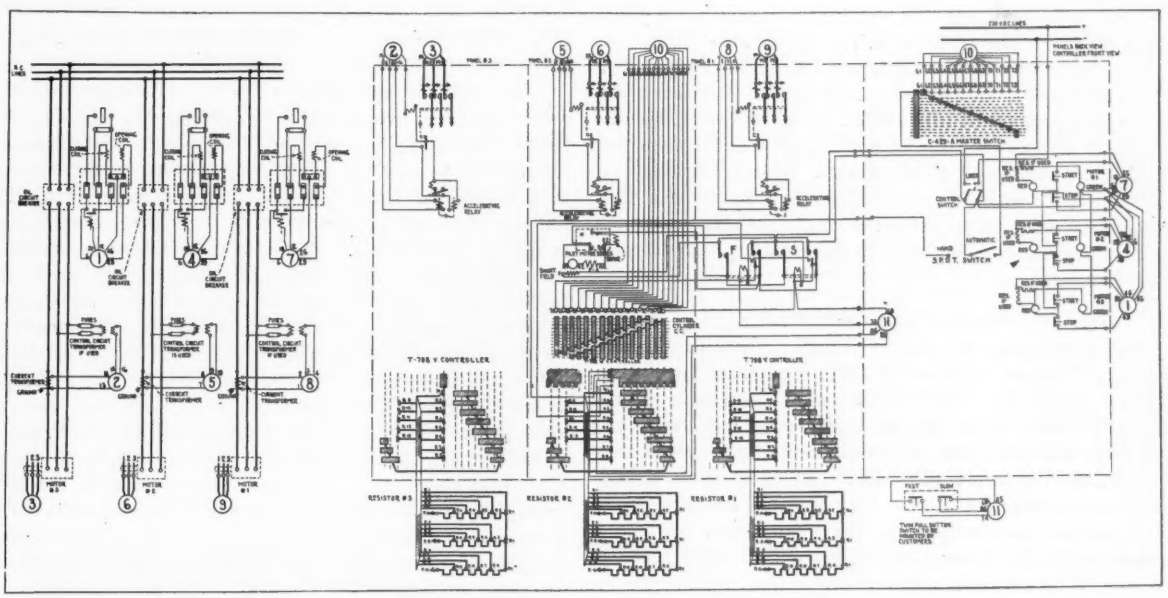


FIG. 2. WIRING DIAGRAM OF PUMPS CONTROL EQUIPMENT

These contactors are also so arranged that they will not reclose until the line voltage has returned to approximately 80 of normal. With this arrangement, it is possible to leave the drum controllers at their last running position on a voltage failure and, when the voltage returns, the motors are automatically brought up to the speed at which they were running before the interruption. This contactor also can be used when not all of the motors are running and it is found necessary to bring the third one on the line. Although the third motor is not running, its drum controller has so moved that its speed setting is the same as the two running motors and, as soon as its line circuit breaker is closed, it will automatically come up to the speed of the other motors and will be controlled in the same way that they are; that is, either by hand or automatically. However, another method of starting may be used which would include throwing the control to hand operation and slowing down the speed of running motors slightly before throwing a third motor on the line. This would prevent throwing the motor on with a small amount of resistance in its secondary and also would prevent a large amount of water being thrown into all three boilers when not needed.

The pumps were supplied by the A. S. Cameron Pump Co. and the motors with control by the General Electric Co.

"The majority of new stations being designed and built at the present time," said Mr. Dodge, "are using a.c. power for all auxiliaries. There are some real reasons for this:

(1) The amount of power required for auxiliaries is of such magnitude in these large plants that it becomes uneconomical to handle this power at low voltage.

(2) Since a.c. motors have been developed to meet practically all operating requirements, there is little excuse for converting all or even part of this power to direct current with the accompanying loss of approximately ten per cent of this power in the conversion equipment. The extra first cost and maintenance of this equipment is also an important factor.

"Several power plants have been designed or built to have an ultimate capacity of 300,000 to 500,000 kw. Assuming 5 per cent of the total as the requirement of the auxiliaries, these plants will use from 15,000 to 25,000 kw. in power for auxiliaries. If this power were to be converted to direct current, it would involve a loss of 1500 to 2500 kw. in the motor generator sets, would require a large investment in conversion equipment and extra copper for handling the power at low voltage, besides extra space in the station for equipment.

"The advantage of the direct current power lies in the use of d.c. motors for the variable speed drives, where a certain saving in losses can be accomplished, depending on the duty cycle required on the variable speed auxiliaries. This may or may not compensate for the losses incurred in conversion equipment.

"There are, however, certain motor drives in the boiler-room where a lower voltage (such as 440 volts, 3 phase a.c.) seems particularly desirable on account of the location of the motors and character of their service. This includes the coal and ash handling equipment, stokers, and clinker grinder motors. These motors are often subjected to very bad operating conditions, including large amounts of coal and ash dust, excessive moisture, gas fumes from the furnaces and wide variations in temperature.

"For such service as this, special insulation is required, and a much greater factor of safety can be obtained if low voltage motors are used than is possible on 2300-v. motors. This also holds true to a less extent as regards the control equipment, and connecting cables. It, therefore, seems desirable to step-down the voltage through transformers for the feeders supplying these motors. Since continuity of service is not absolutely essential on these auxiliaries, this power may come either from the main bus through a station service transformer, or from the auxiliary bus through transformers.

Switches and Reactors

"The question of proper switching equipment for auxiliary feeders is becoming quite a problem in station layout. There are a large number of these switches required for each main unit, and where the auxiliaries are fed from the main bus, or from several house generators in parallel, the interrupting duty and short time current carrying capacity becomes so high that the cost and space requirements are considerable. This can be cut down to a minimum by the proper use of current limiting reactors between the main and auxiliary busses and by the grouping of individual auxiliary motors on feeders with reactors in each feeder. This allows the use of comparatively small switches on the individual motors, with one large switch for each main feeder from the auxiliary bus. A double auxiliary bus is generally used, and a transfer bus is also essential so that the auxiliaries for any unit can be fed from various sources of power.

"The use of enclosed safety truck type switches for feeder and selector switching is desirable since this makes it possible quickly to replace any switch with a spare in case of trouble. Truck type switches also facilitate repairs, inspection and changes and provide a much safer installation than open construction. Where motors are on separate feeders, electrically operated switches are desirable since the control should be located at the motor, and the switches are usually placed in a bus room remote from the motors. Where motors are designed for full voltage starting, the feeder switch becomes the starting switch as no starting box or compensator is required. Low voltage protection should not be used on auxiliary motors. Practically all motors can now be arranged to re-start after a power interruption without any attention from the operator.

"The best practice in protection of auxiliary motors seems to be either balanced differential relay protection of the motor and its cable, or overload relays set high so as to trip only when a fault occurs in the motor or leads. The new thermal overload relay with time characteristic similar to load-temperature characteristics of motors seems well adapted to this service.

"Modern practice in the matter of power supply for auxiliaries seems to be toward the use of auxiliary generators direct-connected to the main units, with several sources of emergency supply. The majority of turbines ordered recently, are equipped with these auxiliary generators.

"At least one large station is now being laid out to take auxiliary power from the main bus through transformers, and another is to have d.c. auxiliaries supplied from large geared house turbine generator sets. These seem to be exceptions to the general rule.

In the discussion of Mr. Dodge's paper, M. J. Lowenberg of Stone and Webster, Inc., took exception to the statement that alternating current is more economical than direct current, although personally he favored alternating current for auxiliaries.

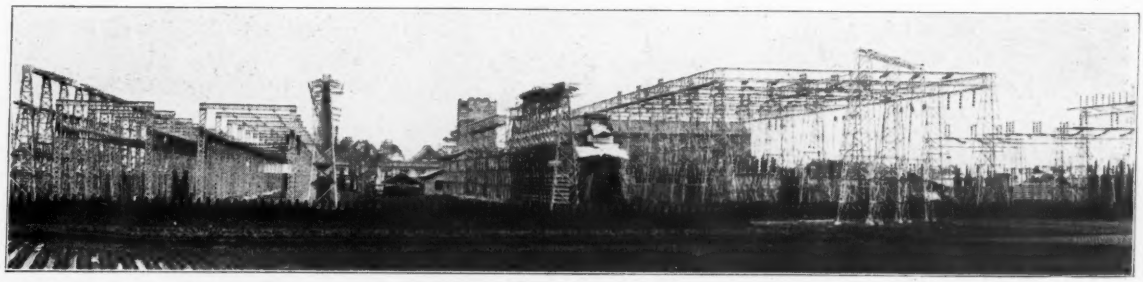
"An analysis we made," said Mr. Lowenberg, "indicated that there is practically no difference in economy between alternating current and direct current auxiliaries, irrespective of how the alternating current or direct current is obtained, that is, whether through motor-generator sets in the case of direct current or transformers, or auxiliary generators in the case of alternating current. The difference in first cost, I must admit, is slightly in favor of alternating current, but that difference when applied to the station as a whole, is small. The difference in economy depends on the duty cycle assumed for the variable speed motors, such as those driving fans and pumps where a great speed range is required. Our own conclusions in the matter were that alternating current appeared as economical as direct current. Since it appeared, however, that there was a constant improvement in the efficiency of variable speed alternating current motors with practically no change in the efficiency of direct current motors, the future appeared in favor of alternating current and was one of the reasons for adopting it."

New Calorimetric Bomb

ON THE occasion of the February 23 meeting of the French Academy of Sciences, M. Moureu read a note regarding a new calorimetric bomb. On December 16, 1918, the bomb belonging to the College of France and constructed by Berthelot in 1885, burst during some experiments of an explosive nature. Part of the bomb was embedded in the ceiling some distance above the work table, which was destroyed.

This bomb had been used for 30 yr. by generations of chemists and had given to the world practically all the figures on heats of combustion which were known at the time of its destruction. Fortunately it had served as a model to a number of small bombs which were in use in different parts of France and in foreign countries.

M. Moureu therefore has undertaken the manufacture of a new bomb. Berthelot's bomb contained a large amount of platinum as a lining; but the present cost of this rare metal being so high, it was decided to replace this with a lining composed of gold, platinum and copper. The whole is rolled together in a homogeneous mass, the copper being soldered to the steel body of the bomb and the inner coating of gold resisting the attack of acids. In this way about 1/10 as much platinum was used as in the old bomb.



Recent Hydro-Electric Developments in Japan

INCREASING POPULARITY OF ELECTRIC POWER LENDS IMPETUS TO THE DEVELOPMENT OF A GREAT GENERATING AND TRANSMISSION SYSTEM

ELECTRIC power holds a relatively more important position in Japan than in any other large country, due mainly to the dearth of coal, oil and other fuels and the existence of many small swift streams that supply cheaply adequate means of producing hydro-electric power. The logical result has been a tremendous development of the hydro-electric industry in Nippon, where, it is said, there is a larger percentage of electrically lighted homes than in any other country. One of the two largest producers of electric power in Japan is the Great Consolidated Electric Power Co., Ltd. It owns twelve generating plants with a total capacity of 255,300 kw. consisting of 154,800 kw. hydro-electric power and 100,500 kw. steam power. It owns a comprehensive high-tension transmission system, having a total length of 503 mi., including 183 mi. of 154,000-v. line and 218 mi. of 77,000-v. line. Its 16 substations have a combined operating and spare capacity of 428,850 kv.a.

These properties are entirely modern and as efficient as any in the United States. American standards of design and construction have been followed, the major portion of equipment installed having been manufactured by the General Electric and Westinghouse companies. Since the inception of the construction program some 5 yr. ago, the company has retained the services of Thebo, Starr and Anderton of San Francisco, consulting engineers. Mr. Anderton is now in Japan in consultation with the engineers and officers of the power company. This company is primarily a wholesaler of power, selling its output under long term contracts to retail systems which distribute power in the cities of Osaka, Nagola, Tokyo, Yokohama, Kyoto and many others, embracing a territory with a population of over 20,000,000. It also supplies power in large quantities direct to interurban railways, electric tramways and many industrial plants. Demand for power in the territory served by the company has shown an average increase of 15 per cent annually during the last 5 or 6 yr.

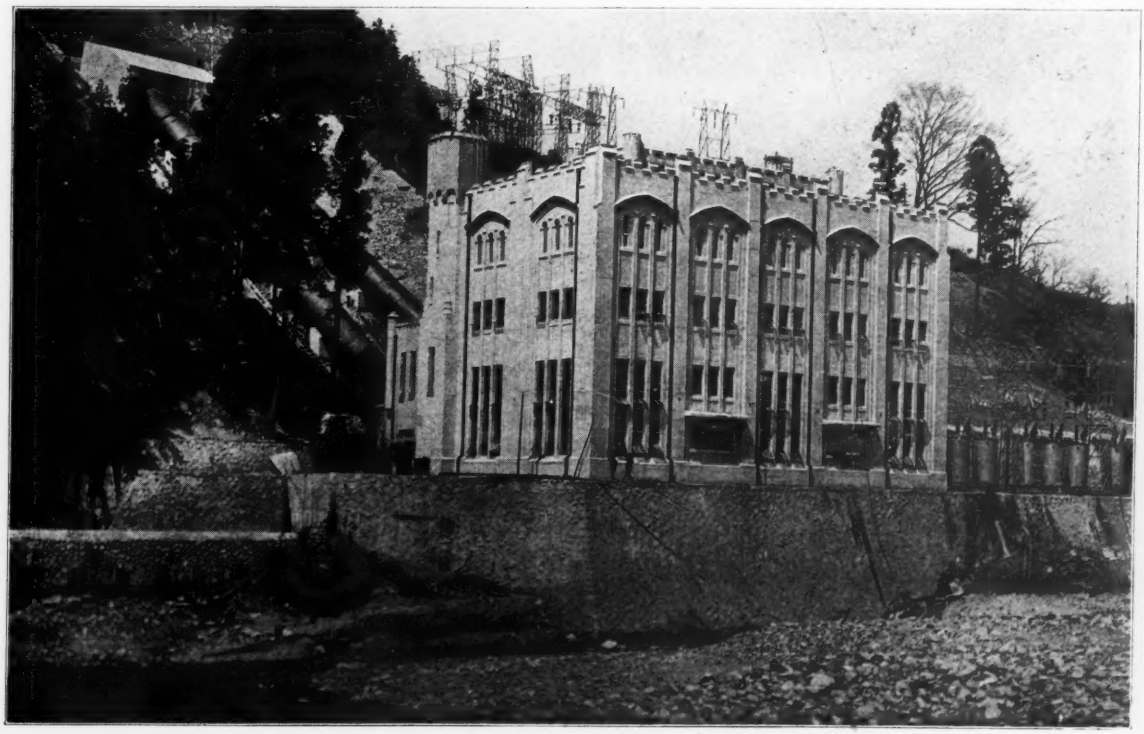


FIG. 1. KISO PLANT NO. 1, 23,100 KW.

FIG. 2. AT YAMAKIKI THIS GREAT FLUME CARRIES WATER FOR 42,700 KW. ACROSS THE OLD RIVER BED

The district served by the company is densely populated and highly developed industrially. No coal is found in the district and but a small amount of oil. If a circle of 150 miles radius be described, with its center at the headquarters of the Kiso River, it will include within its area practically all the more important rivers suitable for hydro-electric development, the principal industrial and political centers. Thus, on the east, Tokio and Yoko-

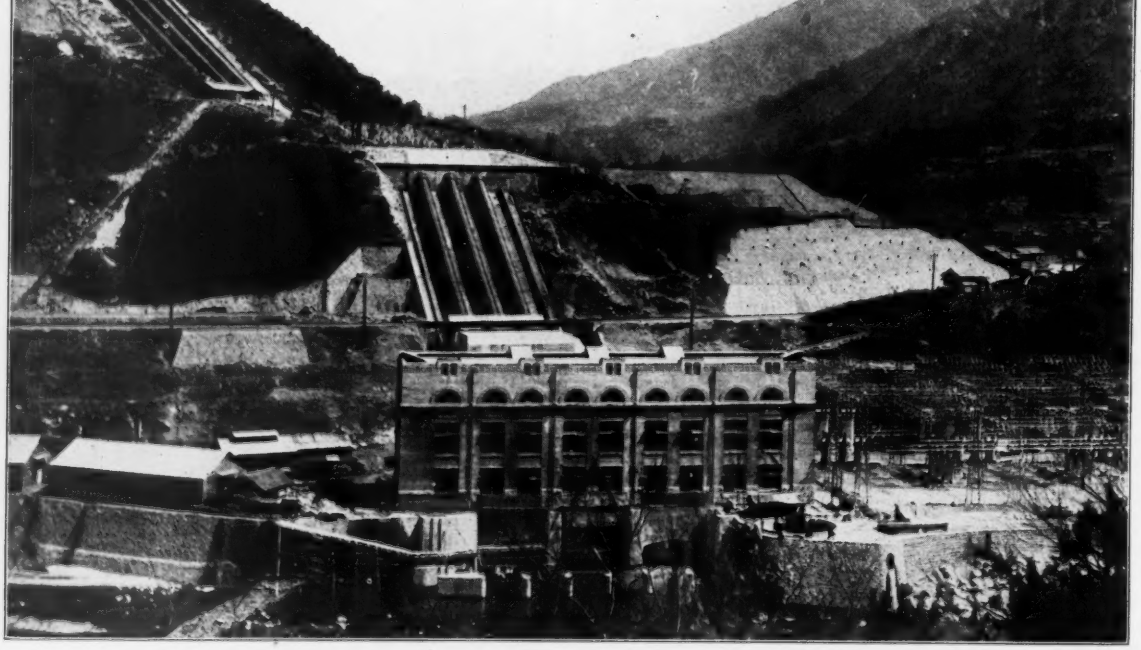


FIG. 3. KISO PLANT NO. 4, 42,700 KW.

hama; on the south Nagoya, Hemmatsu, Yokkaichi, Gifu, Toyohashi, Shidzuoka, Nara and smaller towns and cities; on the west, Osaka, the 'Chicago" of Japan; Kyoto, Kobe, Sakai, etc.; on the north, Toyama, Takaoka, and Kanazawa.

Electric power is becoming daily more and more popular in Japan. The streets of the principal cities are well lighted with street lamps and there is generous use of electric lights in all of the shops, which keep open for business, as a rule, until about ten at night. Considerable power is also used for display purposes and electric signs.

Electricity is becoming increasingly popular for heating purposes. The Imperial hotel in Tokio, which is the largest hotel in Japan, is heated throughout with electricity. Electric cooking devices have been successfully introduced into many homes.

The present system of transmission lines has been so planned that future extensions will finally complete a comprehensive system of high-voltage lines radiating from the Kiso valley, the principal location of the company's generating plants, to all the centers mentioned.

Accompanying are views of some of the hydro-electric plants recently completed by the Great Consolidated Electric Power Co. Figure 1 is Kiso plant No. 1, having a capacity of 23,100 kw. The headpiece shows one of the largest power switching stations in the world, at Osaka, for distributing power to surrounding cities and towns. Figure 2 is the flume line at Yamakiki, leading to Kiso plant No. 4, with capacity of 40,900 kw., shown in Fig. 3. The latest plant completed is Kiso No. 6, at the Great Oi dam, having 42,700 kw. capacity.

Thebo, Starr and Anderton, Inc., consulting engineers of San Francisco superintended the engineering and construction of these huge hydro-electric power projects in the Kiso River Valley, Honshiu, Japan, for the Great Consolidated Electric Power Co., Ltd.

Is Ammonia Combustible?

By W. F. Schaphorst

ON THE MORNING of February 17, the New York City newspapers told of a fire and explosion in rooms occupied by the Greenwich Cheese Co. in which 11 firemen were injured by the explosion of an ammonia tank. The head line says: "Fumes Add to Peril in Loft Blaze." The following are some of the statements made:

"The flames swept over an ammonia tank, causing an explosion of such force as to hurl the firemen down a flight of stairs to the floor below, and rock buildings in the whole block.

"The firemen, bruised and burned, were further endangered by ammonia fumes escaping from the shattered tank. The fumes spread throughout the building."

Farther on, this unusual and interesting statement is found in which ammonia fumes are called "Cold Smoke":

"Besides burns and bruises, the firemen were suffering from 'cold smoke,' a suffocating gaseous property formed by ammonia in a low temperature. Chief Kenlon, who was at the scene, said that in several previous fires at the building firemen have been overcome by "cold smoke."

The writer has already written on this subject in Power Plant Engineering and has maintained that ammonia is not combustible, that the explosion was not caused by the combustibility of ammonia but by the fact that the safety valves on the ammonia receiver or vessel containing the ammonia were not large enough to permit the ammonia gas to escape when needed.

If ammonia gas were readily combustible, it surely would burn in the presence of fire and on burning it would pass upward due to the generation of heat and would not remain close to the ground and suffocate firemen.

While it is true that it is possible to compel ammonia to burn under certain laboratory conditions, it is also well known that it is possible to make iron burn, yet iron is seldom considered combustible. I have yet to learn of a single instance where ammonia has actually burned in a fire or explosion where ammonia fumes were present.

Efficiency of Public-Utility Power Plants Increases

THE DEPARTMENT of the Interior has recently issued a report prepared by the Geological Survey on the production of electricity by public-utility power plants for 1924, which, shows that the average amount of coal used to generate a kilowatt-hour of electricity has decreased 1 lb. in the 5 yr. period since 1919. In 1919, 3.2 lb. of coal were consumed in generating a kilowatt-hour of electricity. In 1924, 2.2 lb. were required. In 1919, a ton of coal when utilized in a public-utility power plant to generate electricity produced 625 kw-hr. In 1924, a ton of coal produced 909 kw-hr. These figures represent an increase of 45 per cent in efficiency in the utilization of fuel. These results are based on the operation of all plants. Some plants are producing nearly 2000 kw-hr. to the ton of coal.

The Survey's report, consisting of some 11 tables, shows that public-utility power plants generated 6 per cent more electricity in 1924 than in 1923, and that nearly 34 per cent of the total output was produced by the use of water power. The amount of coal consumed in generating electricity was nearly 4 per cent less than in 1923, whereas, the amount of fuel oil and natural gas consumed increased 13 and 54 per cent, respectively. California alone consumed 40 per cent of the fuel oil and 46 per cent of the natural gas utilized by public-utility power plants in the United States in generating electricity.

California, after ranking first since 1921 in the production of electricity by the use of water power, dropped into second place in 1924, New York taking first place by a considerable margin. California, however, jumped from eleventh place in production of electricity by the use of fuels in 1923 to fifth place in 1924, outranking Massachusetts and Michigan, leading industrial States. Illinois displaced Pennsylvania as the leading State in the amount of coal used by electric public-utility power plants, but not in the amount of power generated from coal.

Copies of the report for 1924 and a summary of the reports for 1920 to 1923, may be obtained from the Director, Geological Survey, Washington, D. C.

IF ALL THE available power sites on the streams and waterfalls of the world were developed, there would be generated electrical energy totaling 453,000,000 hp., according to a recent estimate made by the United States Geological Survey. Of this power, approximately 29,000,000 hp. have already been developed and put to work, and of this no less than 6,000,000 hp. have been harnessed since 1920.

LETTERS DIRECT FROM THE PLANT

Protecting Large Crankpins

ELABORATE precautions are sometimes taken to protect the circular face of large crankpins when the brass bearing and rod strap are removed. The usual method is to bore out a block the size of the pin, split it and bolt to the pin. In a great many cases, however, means to bore out a block are not at hand but a satisfactory protection can be given the bearing surface of the pin by sawing a number

FIG. 1. BLOCKS OF WOOD NAILED TO STRIP OF TIN

of strips into necessary lengths and tacking to a strip of tin. See Fig. 1. This is then drawn around the circumference as shown in Fig. 2.

Where a solid block cannot be obtained, bored and applied, this scheme can always be resorted to with the assurance of adequate protection to pins of almost any size.

Missouri Valley, Ia. FRANK W. BENTLEY, JR.

Low Condenser Pressure Aids Ice Plant Operation

IN THE April 15 issue, the article under the above title, by A. G. Solomon, contains much useful information. There are one or two statements in it, however, which to my mind do not coincide with practical refrigerating plant operation. The installation of some appliance between the compressor and the condenser for the purpose of removing most of the superheat from the ammonia gas before it reaches the condenser is rather new to me, even though my operating and installation experience with this type of plant covers a period of nearly 15 yr.

Recently there has been installed in this city an ice plant that I believe is about the last word in simplicity and economy; however, we do not find in this plant any precooler for the ammonia gas. An after cooler is connected in the liquid line between the ammonia receiver

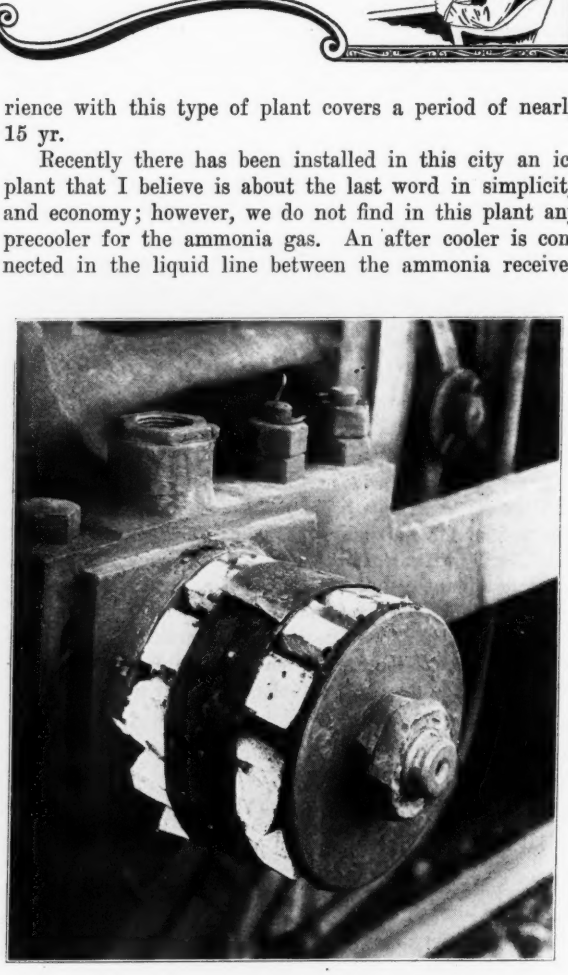


FIG. 2. METHOD OF APPLYING BLOCKS TO PROTECT CRANKPIN SURFACE

and the several expansion valves in the plant and serves to reduce the temperature of the outgoing liquid to within one or two degrees of the temperature of the cooling water.

Why install any additional appliance between the compressor and the condenser for removing the superheat from the ammonia gas, when the same results could be obtained, if necessary, by the use of a larger condenser? If it is desirable to use the waste water, it can be taken from the condenser discharge as well as from the precooler drain. Quoting Mr. Solomon: "By removing heat from the ammonia in the discharge line, the condenser pressure will be lowered 10 to 25 lb. This means a great saving in power or fuel. Circulate as much water as possible through the apparatus for the removal of the superheat." We infer from this that he intends to have us understand that removing the superheat from the compressed ammonia gas will reduce the condenser pressure 10 to 25 lb.

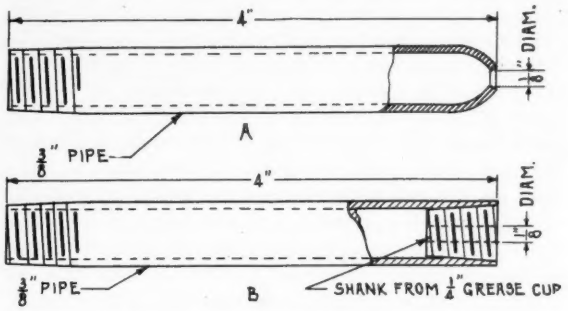
We are operating our refrigerating plant with a condenser pressure of 150 lb. The temperature of saturated ammonia gas at this pressure is about 84 deg. Our gage line is connected direct to the compressor discharge line about 4 ft. from the condenser. The temperature of the discharge line up to the point where the ammonia gas enters the condenser is between 200 and 250 deg. F. The condenser is of the double tube type, with three stands of six pipes each. The superheat is entirely removed from the ammonia gas in the first pass. Now, if we connect our head pressure gage at a point in the condenser where there is no superheat, will it indicate even 10 lb. lower pressure than with its present connection? I think not.

Superheated steam has a definite saturation temperature and pressure. Remove the superheat and the pressure remains the same; I believe the same law holds good for other gases as well. If this reasoning is correct, how will the installation of a precooler between the ammonia compressor and the condenser remove the superheat and thereby reduce the condenser pressure from 10 to 25 lb.? If the condenser is too small, the head pressure will average too high, but not on account of superheat. In such a case it may be cheaper to install some appliance in the discharge line between the compressor and the condenser than to enlarge the latter. If the condenser is dirty, excess head pressure will indicate the fact. In such an event, additional installation would be poor engineering.

A. K. VRADENBURGH.

Steam Jet Repaired With Grease Cup Shank

ON EXAMINING the steam jet smoke-consuming device on one of my boilers recently, I found that some of the steam



A—ORIGINAL JET. B—NEW JET MADE BY SCREWING SHANK OF GREASE CUP INTO NIPPLE

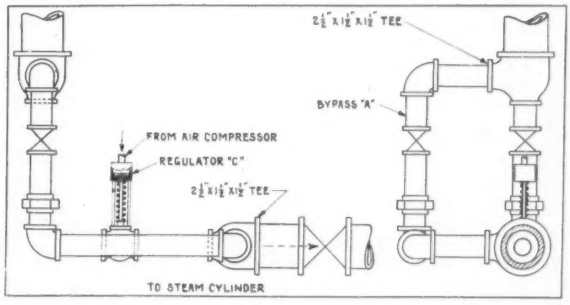
escape through the burned off jets, hence the others received little or no steam. These jets are made of 3/8-in. pipe about 4 in. long with a 1/8-in. hole in them, as shown at A in the sketch.

As I needed these jets immediately, I decided to make them in the following manner. I threaded the inside of a 3/8-in. nipple on one end with a 1/4-in. pipe tap. I had a number of worn out compression grease cups on hand which had a 1/4-in. threaded shank and a 1/8-in. hole through the shank. I screwed one of these shanks into the threaded end of the nipple and then sawed the shank off, thereby making a steam jet, as was required, shown at B. Several of these jets have been in satisfactory use for a number of months.

Milwaukee, Wis. H. A. JAHNKE.

Regulator Bypass Prevents Stalling of Air Compressor

WHEN I installed a pressure regulator for a single cylinder air compressor, I connected a bypass A around the regulator as shown in the sketch. By keeping valve B open just enough to run the pump slowly when the air pressure causes the regulator to shut off, the compressor is prevented from coming to a complete stop. At times the leather cup in the top of the regulator valve C would dry up and allow air to leak past, so that the regulator



SKETCH SHOWING BYPASS CONNECTION AROUND REGULATOR

would not work until a new cup leather was put in. Filling the cup leather with hard grease kept it soft and made it last much longer.

Brookline, Mass. R. B. ROWE.

Simple Pulley Guards Not Always Safe

IN THE April 1 issue a belt and pulley guard described by Frank W. Bentley, Jr., although partially effective, has certain limitations which, in the interests of safety, it is deemed advisable to mention.

This type of guard should not be installed where belt speeds are high, for the reason that it does not provide adequate protection in the event of belt breakage.

In such a case there is the possibility that the loose end of the broken belt will strike someone and, in fact, the "whip" action may become greatly accelerated if the belt starts to wrap around one of the pipes.

The writer has known of one death from this cause and although the circumstances were rather unusual, yet in view of the serious consequences, it is important that careful consideration be given the design and construction of belt drives. The drive in this instance was horizontal, the size of the belt about 3 by 1/4 in., and the motor was controlled by a switch directly in line with the action of the belt. Upon starting, the belt broke at the splice and the flying belt struck the operator with such terrific force that he was killed instantly.

As a means of preventing personal contact with the belt in ordinary operation, the guard described by Mr. Bentley should be satisfactory but it does not provide for such emergencies as described. This type of guard may serve the purpose for years without serious difficulty but there is always a potential danger and it will never insure maximum safety where high speed is found.

Chicago, Ill. F. R. ZIMMERMAN.

QUESTIONS AND ANSWERS

Study of Slide Valve Action

WHAT IS the earliest cutoff that can be given a D slide valve? READER.

A. The easiest way to study valve action is by Bilgram valve diagrams. In Fig. 1, AB represents the stroke of the engine, and A′ B′ the diameter of the crank circle. Oo is the throw of the eccentric, ed the lead, oL the angle of advance. In Fig. 1 the lead is $\frac{1}{16}$ in., eccentric throw 1⅛ in., steam lap ½ in., exhaust lap ⅛ in. negative.

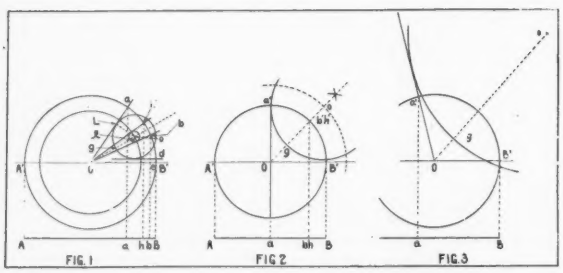


FIG. 1. DIAGRAM FOR CUTOFF ⅝ STROKE
FIG. 2. DIAGRAM FOR CUTOFF ½ STROKE
FIG. 3. DIAGRAM FOR CUTOFF ⅜ STROKE

Steam port opening at extreme travel is shown by Og, ⅝ in., cutoff position head end for the crank Oa, and piston positions at a for cutoff, at h for release head end and at b for compression, crank end.

To get cutoff at ½ stroke as in Fig. 2 and keep port opening ⅝ in. eccentric throw has to increase to 2 in., Oo steam lap to 1⅜ in. With exhaust, lap zero, this brings release and compression at b and h 85 per cent of the stroke. As cutoff is brought earlier, travel and lap increase, thus increasing the size of the valve and the power used up in friction.

Also it is difficult to get proper release and compression. For these reasons, cutoff is not usual with a D slide valve at earlier than ⅝ stroke, although by allowing negative lead, valve openings after the crank has reached dead center, cutoff can be carried down to ⅜ stroke, as shown in Fig. 3, but with extreme results as to valve travel and lap, the former, twice Oo, being 7.5 in. and the latter og, 3⅛ in.

Static Electricity on Belt Caused by Contact of Surfaces

WHAT CAUSES the static electricity on a belt? Is it the actual friction between the belt and pulley or the slipping of the belt on the pulley? L. B.

A. It seems to be the opinion of modern electrical investigators that there is no such thing as frictional electricity or, as it is sometimes called, "tribo-electricity," to which has been attributed the electrification of belting. It is believed, instead, that in most cases of this kind the high-tension electrical discharges are caused by the fact that close contact between two surfaces allows one surface to release its negative electrons to the other surface, thus establishing a difference of potential between them.

Let us assume that two materials, a collodion film upon a glass surface, have a small difference of potential at the contact. Assume this difference to be only two or three volts and the distance between film and glass to be molecular, much less than one-millionth of an inch. Now if we start to separate those surfaces, doubling their distance apart, the voltage becomes double what it was before. If we double it again, the voltage will double again. Evidently, it will take a great many doublings of this distance to give a perceptible or measurable separation between the two surfaces. At each doubling of the distance between the surfaces, the voltage increases almost in proportion and this voltage, which was at first only two or three volts, in the end becomes many thousands. It is believed that this is the cause of high-tension electricity; not friction, but contact due to friction and effects due to contact without friction.

This is the action that takes place with a belt and pulley. On account of the edge effect, a narrow belt does not yield anything like the potential that is obtained from a much wider belt under similar circumstances. Moreover, if the belt runs over a small pulley, the separation of the belt from it is abrupt and a recombination of the electricity of the belt with that of the pulley surfaces of opposite name takes place as the belt is leaving. When the diameter of the pulley is large, the separation is not so rapid and the recombination cannot take place so readily.

It is possible to obtain spark discharges of 8 or 10 in. in length from a moderate-size belt running over a small pulley. It has been observed that in the case of a wide belt, such as 4 or 5 ft. or more, such a belt gave sparks 4 or 5 ft. long, indicating the presence of an enormous voltage, possibly as much as 1,000,000 v. or more. In the latter case, the charges on the surfaces acquired by contact were separated gradually and the change in capacity effect was so slight that the potential kept rising without disruptive sparks as the belt left the pulley surface. The separation was made at a rate slow enough to conserve the charge on the belt.

There are many reasons for believing that the arrangement of the molecules at the bounding surfaces of bodies is different in many cases from the interior arrangement. It is not possible here to go into the details of these investigations, but they tend to show that the surface conditions bulk large in many of the phenomena of nature. The contacting surfaces acquire a certain sort of electrical equilibrium which involves the existence of the plus or minus charges in a bound state between the two surfaces and a possible exchange of electrons.

We may say that electrons are displaced in the process so that one body loses negative electrons and becomes positive, and the other gains the lost electrons. During incipient separation the charges continue to be measurably bound, but cannot reunite across the space of separation on account of the air insulation which has been established between them. As the separation is attended with lowered capacity, the potential rises. It may be said in conclusion that probably there is no such thing as frictional electricity, as distinguished from that produced at the contact of dissimilar surfaces.

For a more detailed discussion, the reader is referred to a report of a lecture by Elihu Thomson, delivered in 1922 before the Lynn section of the A. I. E. E.; this report was published in the May 15, 1922, issue of the Journal of the A. I. E. E.

Steam Purifiers Cause Small Fuel Loss

In the March 15 issue, in an article entitled "Steam Purifiers Cause Small Fuel Loss," the calculation and use of the factor of evaporation is instructive. In this article the following formula is given:

$$\text{Factor of evaporation} = \frac{H - L \times (M \div 100) - h}{971.7}$$

In the formula H equals the total heat of the steam at 115 lb. per sq. in. gage or 130 lb. absolute; L is the latent heat of evaporation at that pressure; M equals the per cent of moisture (assumed to be 6 per cent); h, as stated in the article, equals the heat of the liquid above feed water temperature. The quantity h in this formula is incorrectly defined, since it should denote the heat of the liquid coming to the boiler, if the other quantities are to remain the same. Substituting the values given in Goodenough's steam table, we find the factor of evaporation to be as follows:

$$\text{F. of E.} = \frac{1192.6 - (874.4 \times 0.060 - 180}{971.7} = 0.988$$

instead of 1.04 as given in the above-mentioned article.

In order to determine the weight of water that must be evaporated to make a boiler horsepower at 115 lb. gage (the feed entering at 212 deg.) the quantity 34.5 must be divided by 0.988, giving 34.91 lb. as the required amount. Continuing the calculations, since the boiler feed water entered at 212 deg., each pound of water must have 135.4 B.t.u. added to it in order to make its temperature 347.4 deg. Since 6 per cent of the feed water is wasted for every boiler horsepower developed, this means that $135.4 \times 34.91 \times 0.06 = 284$ B.t.u. are thrown away. Considering that 49 cu. ft. of gas containing 965 B.t.u. per cu. ft. are used to develop one boiler horsepower, the fuel loss caused by the purifier is

$$\frac{284}{49 \times 965} = 0.0061,$$

or about 0.61 per cent instead of 0.45 per cent as was given.

At present a boiler horsepower is defined as the evaporation of 34.5 lb. of water per hour, from and at 212 deg. F. Those who are not familiar with the early history of steam, will perhaps wonder why such a number was selected. In the boiler book "Steam," issued by the Babcock and Wilcox Company, the following statement should be of interest:

"To do away with the confusion resulting from an indefinite meaning of the term boiler horsepower, the Committee of Judges in charge of the boiler trials at the Centennial Exposition at Philadelphia in 1876 ascertained that a good engine of the type prevailing at the time required approximately 30 lb. of steam per hour per horsepower developed. In order to establish a relation between the engine power and the size of a boiler required to develop that power, they recommended that an evaporation of 30 lb. of water from an initial temperature of 100 deg. F. to steam at 70 lb. gage pressure be considered as one boiler horsepower. This recommendation which was standardized by the American Society of Mechanical Engineers in 1889 has been, until recently, generally accepted as standard by American engineers."

As pressures have risen considerably since 1889, changes in standards have become necessary. As engineers were loth to give up the commonly accepted idea of a boiler horsepower being developed when 30 lb. of water per hour were evaporated, it was decided to refer all conditions to one standard heat plane or base; namely, that in which the feed water enters at 212 deg. and is generated into steam under atmospheric pressure, which for dry saturated steam is equivalent to a pressure of 212 deg. F. It is thus seen that the heat added to the feed water is merely the latent heat of vaporization, which, according to Marks and Davis, is 970 B.t.u. per lb. Goodenough gives a slightly higher value, 971.7. The factor of evaporation for water entering a boiler at 100 deg. F. under a pressure of 70 lb. gage is 1.1494. Using this factor, 30×1.494 becomes 34.482, generally accepted as 34.5.

Lafayette, Ind. John A. Needy.

Corliss Engine Pounds After Being Overhauled

In my opinion, the pound in the Corliss engine described by C. E. B. in the April 15 issue is not caused by improper valve setting. Let us assume that all main bearings, crankpin, and crosshead, besides all valve-gear parts, are properly adjusted and tight. The pound may be caused by a side slap of the crank or main shaft against the bearing or housing, due to misalinement or too much play between the crank and collar on each side of the shaft on the main bearing. The crankpin may be loose or the piston on the piston rod. If a new piston has been installed and it is thicker than the old one, the clearance for compression is reduced, or the piston may be hitting either one of the cylinder heads.

If the eccentric is secured to the shaft by set screws countersunk into the shaft, these screws may have worked loose and at each revolution may create a rumble. If a flywheel is installed upon this unit for storage of reserve energy and for balance, the links at the joints of this wheel may be loose, or the wheel may be loose on the shaft.

The main engine frame may be cracked at the main journals or at flange connections at steam cylinder; such cracks might be hidden from view by paint or grease. Last, but not least, if a separator is installed above throttle valve, see that it is all together inside and that the steam trap which handle the condensate therefrom is also functioning properly.

Galveston, Texas. H. W. Rose.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

1925—A Year of Healthy Business

As months pass, it becomes more and more evident, that there will be no boom this year. That is good. Dating back to the November elections, industrialists in general looked forward with anticipation to 1925. Outward expressions of hope that there would be no business "boom" were many during the early part of the year. At the same time there was considerable inward hoping that a boom would come in the particular case of each wisher. That the outwardly damned and inwardly hoped-for boom did not materialize is the reason why many are now questioning business conditions. Many of us merely hoped for too much and are now disappointed.

Industrial conditions today are satisfactory. True, there is some evidence of dullness, notably in the field of merchandising. A gentle tapering off is already felt in the iron and steel trade, which may reflect itself to some extent in other lines during July and August. But production operations in general are running 83 per cent of capacity, with the present force working 93 per cent of full time. Unemployment is at a low level and, as soon as outdoor work attains full swing, there will be practically no surplus of labor.

Probably one important point requiring attention during the mid-summer period of quiet will be the question of wage scales. This problem should be considered carefully. Our scale of wages is still too high. Taking London wage scales as 100 per cent, our wages stand at 200 per cent, while Belgium is only 60 per cent of London, Germany 65 per cent, France 75 per cent and Austria 50 per cent. That we need to consider our wage scale in this connection is proved by the fact that France and Belgium are underbidding us on iron and steel contracts as far inland as Detroit, while Germany is rapidly regaining dominance in toys and chemicals. This is forcing many American plants to curb their production. In most cases, wage cuts would improve worker's yearly earnings, because a reduction in the scale would mean full-time work the year round, practically eliminating part-time and lay-offs. Almost without exception, industrial groups accepting a lower unit rate of pay have shown steadier employment and substantial increases in total earnings.

Present day trade is durable and safe. For those who can plan without speculation, produce economically and sell without the stimulus of a boom, it is profitable. The problem of the time is not so much worrying over the rate of the continuing volume of business as the need of realizing that we are in for a period of active competition.

And What Will Poor Congress Do Then?

During the Sixty-Eighth Congress, more consideration was given to Muscle Shoals than to any other measure. It was legislated up one side and down the other, running the gauntlet of both House and Senate, gathering amendments here and dropping them there, until finally, after the fashion set by Pontius Pilate, Congress washed its hands of the whole affair by recommending to the President that a commission be appointed to study the question in all its phases so that, in another session, wiser legislation might be enacted.

In the meantime construction had been progressing at a reasonable rate. Muscle Shoals should generate electricity in July or August. But where is it going to be used? Congress, to whom delay means nothing, has made no provision for the disposition of the power and it will not assemble again until December.

No doubt the much maligned power companies in the Shoals district will assume the responsibility of distributing the power generated throughout the Southeast. By so doing they will be "turning the other cheek" for, during the past two years, they have received a great deal of unjust abuse. What our deliberate Congress will do after such a three or four month's demonstration, time alone can tell. We have hopes (but not much faith) that early in the coming session the Muscle Shoals matter will be wisely and definitely closed.

The whole matter is something that should make those engaged in the power industry thankful that they are somewhat free from governmental interference. In a small way, the power man can now sympathize with the railroad operator. The transportation field has been full of "Muscle Shoals" for many years. Legislative control and congressional inaction have meant delays, harassings and sleepless nights for railroad men. The power field, seeing the Muscle Shoals incident, may well congratulate itself on its freedom from bureaucratic dabblings.

Commercial Aviation Develops Rapidly

Transportation, since the beginning of time, has been a problem of major proportions. The ability to move objects, people or thought has, in large measure, determined the progress of all peoples. Transportation is basic in all things industrial and social.

Time was when we mapped our industrial enterprises and shaped our commercial plans to fit wagon haulage, canal boats and warehouses as transportation. Passenger traffic was confined to stage-coach travel, operating over private and public turnpikes. The steam railroad destroyed this system. The past sixty years has brought far reaching developments in the steam-propelled utility, with even greater developments in industry and agriculture.

Today, the motor vehicle, especially the bus and the truck, is proving a keen competitor to the steam railroad. Many railroads have adopted the motor truck for certain short-haul freight traffic, while others are operating bus lines in connection with their rail transportation. The motor vehicle is approaching its final stage of development. Few revolutionary changes remain. The elimination of noise, the adoption of the pull, instead of the push principle (four-wheel drive, perhaps) and the development of a more substantial tire, are the last major improvements to be made.

And so we find ourselves turning to aviation—which is an established fact now in several European countries and which is on a fairly sound basis in the United States. Much remains to be done in the establishment of aviation as a basic industry, however. Improved machines, more and larger landing fields, aerial lighthouses, and much needed legislation are still to come. But we now have an

excellent start, and it is a beginning which everyone should encourage and aid so far as possible.

With the active assistance of the Ford interests, 1925 should see commercial aviation firmly on its feet and 1926 in quite extensive use. Like motor vehicles, aerial transportation will remain supplementary rather than competitive to our rail transportation for many years to come. Changes and developments, however, are being made ever more quickly and we believe we can look forward to airplane service as becoming a necessity in a few years. It took hundreds of years to make the change from the two-wheeled cart to the four-wheel wagon. About 100 yr. were required for the development of the steam railroad. Only about 30 yr. were needed for the development of the automobile. There is every reason to believe that development of aerial transportation will show corresponding speed.

Now That Your Congressman Is Home—Look Him Over

All is quiet along the Potomac. Washington holds few statesmen, and the Capitol sleeps. But though the Capitol is silent, the White House is busy with the affairs of the nation, which again gives evidence that the silver tongued orator plays a small part in making our Government a success in comparison to the silent worker who is always ready to receive information or facilitate the work of others.

Civic indifference to national welfare should not attend this period of political quiet. This is the citizen's best opportunity to take his political stock inventory. He can review the recent session, study something of the men who appeared there and, in many cases, talk directly with the congressional representative from his district. Now is a much better time to study up your Congressman or Senator than next December when Congress has again assembled in the Capitol. You can—and should—find out how he stands on impending legislation and what he is going to do in the cases most interesting to you. In this quiet of the political tom-toms you can best assess your politics, your politicians, your government officials, and the relationship of yourself to your government.

From Doers to Doles

The men who framed the Constitution and established the United States of America held firmly to the belief that it was their duty to support their Government, both national and state.

The modern notion seems to be that the government should support the people, for out in California a bill has been introduced in the state legislature which would provide for the payment of $30 a month to all persons 65 yr. of age or older and who have an income of less than $300 a year or property valued at less than $5000. If this bill passes, more than 60,000 people in California will be found eligible and the tax burden of that state will be immediately increased by over $21,000,000. Just what the increased taxation will total in future years only Heaven knows.

Considering the legislative trend of the last few years and the rapidly developing socialistic tendencies, it isn't altogether surprising that we find ourselves leaning toward old-age pensions. It is the next step in the general direction of substituting the dependent for the independent, destruction for construction, the workless for the worker, the dole for the doer, the wheel chair for the plow.

The Real Founders of the Republic

New England has been celebrating the 150th anniversary of the battles of Concord and Lexington. A national significance was given the event by the presence of Vice-President Dawes and General Pershing. But it was largely a local affair, and few other sections of the country have paid much attention to the anniversary.

In these days of rapid progress it is so easy to forget the men who sacrificed themselves for the founding of this Republic. Many of us remember only the politicians who, taking no physical part in the Revolution, fastened their names in history solely with their tongues. Without the aid of Longfellow, Paul Revere would probably have made little lasting impression. We doubt whether you who are reading this can give the name of a single Minute Man. (Neither can we.)

The World's "Village Blacksmith"

Nearly 4½ billion pounds, sterling (nearly 22 billion dollars) is the total of all inter-allied debts, both funded and unfunded. This total includes accrued interest. Of this sum, $11,202,000,000 is owing to the United States Treasury, a little over half of which has been funded.

In the indebtedness tangle, Great Britain has outstanding a total credit of 2008 million pounds sterling while she owes 940 million pounds. France owes 1423 million pounds, carrying on her books only 179 million pounds as being owed to her. Italy can hope to collect only 7 million pounds, while she owes other nations a total of 969 million pounds. As for us, we have outstanding a total of 2305 million pounds sterling credit, while owing practically nothing.

In more than one way it is fine to be in the position of the village blacksmith and "owe not any man," at the same time enjoy the knowledge that there is incoming something over eleven billion dollars. Such a condition, however, is not without its harmful effects, as it makes it all the more difficult for other countries to get back to the gold standard. We are an island of gold surrounded by a world of paper currencies and it is quite possible that because thereof other countries may establish closer commercial relations with each other than with the United States. These attendant difficulties have not seriously affected our international commerce as yet but we can hope for no far reaching or permanent betterment of trade conditions until at least England and France have re-established their currencies into fixed relations to gold.

England is in a much better position to make the advance than is France. Even England, however, finds it extremely difficult to take the return step—and probably will not do so just at this time. The Government there has adopted a mild deflation policy, in an effort to get back to the basic gold foundation, and with the result that the business outlook in Britain is not good. All leading industries are in depression, according to the United Business Service—especially the colleries and shipping. The lace, glassware, tire, brush, carpet, gas mantle, hollowware, silk, automotive and radio industries have all asked for protection. The steel industry is only fair and the cotton mills are on part time. Probably the earliest adjustment Britain can hope for will be in 1926.

EDITORIAL COMMENT

Going Down!

In this day and age an engineer may be greatly confused by hearing the words "going down," for he would have to inquire whether or not they referred to elevators or the fuel required per unit of power. Any engineer who is so "prewar" as to imagine that he is operating on an economical basis when using 18,000 B.t.u. per kw. should read the article on page 570 of this issue.

He will find there the calm announcement from the new Philo Station of the American Gas & Electric Co., that they have no use whatever for more than 13,715 B.t.u. with which to make one kilowatt-hour and they have found with that low expenditure of energy their kilowatts are just as good as those produced at a higher cost.

Now, then, for the logical question, "How do they do it?" In the first place, there is that prime essential, namely, design. The station had to be planned for the work which was to be expected of it. Equipment had to be so selected that high economy could be expected of it. A market was established so that this plant could manufacture and deliver electric power upon an economical basis. Nature was taken advantage of to the extent that the power ordinarily consumed by condenser circulating pumps is not required for ten months out of the year.

Finally, there is the personnel of the plant. Equipment, fuel and a demand for power bear no relation to economy unless the men who are on the job day in and day out know their business and attend strictly to it. Thus, again we find that economy results not from one factor but from the accumulative results of many factors.

"Going down?" The record at Philo Station gives a new mark to shoot at.

Scrapping the Obsolete

Industrial America owes much of its growth to that characteristic of aggressiveness with which our industrialists have constantly sought improved methods of production. Probably some of us have not as yet come to the full realization that a plant producing power is as much a manufacturing plant as is one which produces furniture or steel products.

It has been found necessary in plants such as those last named to scrap wood working and steel producing machinery when it was found that by so doing greater output or greater economy could be obtained. This policy has not been so popular among the producers of power, except possibly among a few of the larger and more progressive utility companies.

It is said of Edison that he was constantly searching for information and a better way of doing things. He would throw into the discard hundreds of thousands of dollars worth of unproductive experimental work just as soon as he found a better way of doing the thing to which it applied. More of this spirit is needed by those who are producing the country's power. Its consequences will be felt immediately by those great industrial institutions which are specializing in the manufacture of power equipment. They will respond to the demand placed upon them with the result that equipment will be improved more rapidly and methods will be more productive, resulting in greater economy of power production which in turn means conservation of fuel and a greater return upon investment.

Possibilities of the Gas Turbine

As a result of the increasing interest in the general subject of internal combustion engines and the part they will probably play in the engineering of the future, engineers often ask, "How about the internal combustion turbine?" The amount of investigation that has been done on the gas turbine, especially in Europe, is surprising. Experiments by Rateau and others may be noted; several interesting papers have recently been presented on the subject in England. In this country, investigations have been carried out by Messrs. Marks and Danilov and their report was presented at the winter meeting of the A. S. M. E. Taken all together, these reports are not encouraging. They indicate that, while there are possibilities in this type of prime mover, the practical limitations of construction and operation at present prevent the attainment of the improved efficiencies often expected.

If the high thermal efficiency of the Diesel engine could be combined with the mechanical simplicity of the steam turbine, the gain would be great. But this expectation, according to Messrs. Marks and Danilov, rests on an analogy with the steam turbine that must be dismissed at once. If a gas turbine could use a more extended temperature and pressure range than is possible with the reciprocating engine, a result similar to the advantage of the large condensing turbine over the reciprocating engine might be possible. But complications are introduced by the need for regeneration, the present impracticability of pressure compounding, the negative work of precompression, cooling of the casing and many other factors. Then, too, there is the question of finding material capable of sustaining the pressures and temperatures involved. In the evolution of the present steam turbine the lack of suitable material to stand the speed was a handicap until Parsons resolved the difficulty by compounding. Some investigators believe it is this question of material that prevents the success of the gas turbine.

At present, the best efficiency based on brake horsepower that has yet been obtained with the gas turbine is about 14 per cent, as against the brake thermal efficiencies of 34 per cent often obtained with Diesel engines. Yet it is well not to be too pessimistic. Many of the early difficulties encountered with the steam turbine have been overcome; the recent mercury turbine installation has also come in for its share of criticism. The ingenuity of the scientist, however, is not yet exhausted. In any event, however dark the present outlook for the gas turbine, the exhaustive investigations of it that have already been made and that are still going on will form a valuable contribution to the whole body of modern scientific knowledge.

The Need for Impartial Consideration of Facts

In arriving at a correct judgment of a disputed question much depends upon the attitude of mind we preserve while listening to or taking part in the controversy. If we are to arrive at the true solution of any question it is essential to maintain a neutral state of mind and not allow our opinions to be biased by personal prejudices. This is as true in the consideration of engineering questions as it is of questions of a more general nature.

In engineering we are concerned primarily with the accumulation, study and analysis of facts. If these facts are correctly presented and if we are capable of classifying them and weighing them in the abstract, without regard to our personal interest in the final result, one way or another, we cannot fail to arrive at the truth.

Unfortunately, this impartial attitude so necessary to a correct understanding of the issue involved is extremely difficult to assume, and often this lack of impartiality becomes an obstacle in the path of progress. Much time and effort is expended uselessly by advocates of certain measures, not in advancing their own ideas and theories, but in attacking those of opposing factions or individuals. In commercial practice this, too, often leads to an exaggeration or distortion of facts to prove the case of the interested party, a state of affairs which is decidedly unscientific.

In questions of engineering practice or in the case of a new development the controversial element often overshadows the basic issue involved. Many seem to think that in order to maintain one's professional standing so to speak, it is necessary to ally one's views or sympathies with one side or the other, forgetting the fact that in any question of this sort, both sides may possess certain elements of truth. What is necessary is not the taking of a definite position with either side but a careful consideration of the merits and liabilities so that the true merits of each side of the issue may be disclosed and that in the end they may be coordinated to the greatest possible benefit of all concerned.

It is needless to cite specific instances. The history of engineering is replete with them and usually, after much time had been wasted in proving the propositions advocated by each side impracticable, the heat of the controversy abated and each side proceeded along its own natural course of development.

In calling attention to this matter our plea is for a more scientific attitude with regard to engineering developments. One of the curses of any industry is the distortion and exaggeration of facts to prove the case of the interested party and commercial engineering, we regret to say, has not been entirely free from this condition. Because of the frailties of human nature this condition is difficult to eliminate but in engineering practice, because of its scientific nature, every effort should be made to avoid it.

Clearing Houses for Engineering Information

From the designer of the simplest mechanical tool to the manager of the most complex industrial organization, engineers have shown a remarkable spirit of cooperation. Engineering as it is known today is little more than a generation old, yet throughout the entire civilized world technical information on design and construction is available.

In the mechanical field, one of the foremost channels through which engineering information has been disseminated is the American Society of Mechanical Engineers and we have only to turn this page to learn of the latest contributions of this society as presented at the recent spring meeting in Milwaukee. A study of the program presented at this convention shows papers on every branch of the mechanical field from the generation of power from waterfalls to the examination of metals by X-rays. These subjects are not only presented and discussed at the meetings but are incorporated in the permanent records of the society where anybody interested, whether member or nonmember, may have access to them.

What is true of the American Society of Mechanical Engineers in this respect is also true of other engineering organizations serving other fields. The papers and researches of each are made available to the other. In this way all the various engineering organizations all over the world constitute a great clearing house for engineering information.

This interchange of information is one of the fundamental characteristics of the engineering profession and it, more than anything else, is responsible for the tremendous advancement in all engineering fields witnessed in recent years.

Have You Buried Your Talent?

Somewhere in the Bible there's a parable of three men who were given talents to invest for their employer. Through fear of losing the talent entrusted to him, one of them buried it where it was useless to himself or his fellow man. But his associates, with more ambition and willingness to co-operate with others, made use of their trust by judicious investment and soon doubled their treasure. That parable, first told by the Master some nineteen hundred years ago, still carries a message for men in all walks of life. We in the field of power plant engineering would do well to profit by the lesson it teaches.

Engineers in general, and we power plant engineers in particular, are prone to diffidence and reticence. We are too individual. There is not enough exchange of confidence. Of the many thousands in the country, comparatively few have affiliated themselves with an engineering society. Going still further, we find that, among those who do belong to a society, only a small per cent are concerned with its activities.

No matter how humble his job, everyone learns interesting things about his work which the other fellow doesn't know or hasn't discovered. It may, perhaps, seem too trivial and commonplace to talk about. But great discoveries and inventions often hinge on apparent trivialities which may seem of little consequence to you but will have a world of meaning for your brother engineer.

Successful operation of power plant equipment provides a broader field for the exercise of ingenuity than almost any other line of endeavor. The engineer in charge must be a jack-of-all trades and besides have a good knowledge of steam and combustion engineering thrown in for good measure. Comparatively few, however, have acquired their knowledge entirely through their own efforts. Association with other engineers and exchange of ideas is often better than text books and so, whether you belong to an engineering society or not, Power Plant Engineering is always ready and willing to help you. But it can only serve you in the degree in which you serve others. Emerson said: "The only way to have a friend is to be one." Let's hear from you.

Interest in Power Shown at A. S. M. E. Meeting

MANY PAPERS DEALING WITH PROBLEMS CONFRONTING POWER PLANT ENGINEERS WERE PRESENTED AT SPRING MEETING OF A. S. M. E., IN MILWAUKEE

FROM May 18 to 21 the city of Milwaukee was host to the mechanical and refrigerating engineers who visited the city for the purpose of attending the Spring Meeting of the American Society of Mechanical Engineers, the American Society of Refrigerating Engineers' meeting, and the Midwest Power Show. During the entire four days practically all the factories of the city were open to visiting engineers and an interesting social program was arranged for each day.

As has been customary for several years, the technical program of the A. S. M. E. was conducted in simultaneous sessions and, each day, meetings of vital interest to power plant engineers were held. Standards were proposed for steel flanges and flanged fittings for pressures of 250, 400, 600 and 900 lb., for cast-iron screwed fittings for pressures of 125 and 250 lb., for malleable iron screwed fittings for 150 lb. pressure and for identification of piping systems. There were also public hearings on the boiler and test codes of the society.

In the paragraphs which follow are given digests of only those papers presented before the A. S. M. E. which are of particular interest to the power plant field.

Operating Problems Feature of Hydroelectric Session

In a paper entitled "Mechanical Problems of Hydraulic-Turbine Design, William M. White, manager and chief engineer, hydraulic department of the Allis-Chalmers Mfg. Co., discussed in detail many of the features of the 70,000-hp. unit which was recently put into operation in the plant of the Niagara Falls Power Co. He stated that although an excellent foundation for an American type of turbine development had been laid by such men as Francis, there is yet much to be done although constant fixing the water passages to, through and from the turbine have been quite definitely outlined and the types of auxiliary apparatus to provide for the convenient, economical and safe operation of the turbine have been fairly well fixed.

During the hydro-electric session, F. A. Allner, general superintendent of the Pennsylvania Water and Power Co., read a paper entitled "The Parallel Operation of Hydro and Steam Plants." He stated that the economical service of hydro power is usually expressed as replacement value of the equivalent amount of steam power. This comprises two different elements: one, the steam investment cost of hydro demand service; the other, the steam generating cost of the hydro energy delivered to the load system. A hydro development which is not equipped with seasonal storage can render the greatest demand service to a given system load if, on the days of greatest steam demand on the system coinciding with minimum flow, the hydro plant supplies the peaks and the steam plant the base of the system load.

"Mechanical Features Affecting the Reliable and Economical Operation of Hydro-Electric Plants" was the subject of a paper also presented at the hydro-electric session by E. A. Dow, mechanical engineer of the New England Power Construction Company. In this paper the subjects of flashboards, trashracks, rack rakes, sluice and headgates, penstock valves, air vents and discharge measuring devices, from the standpoint of economy and reliability of operation, were discussed.

Pulverized Coal Furnaces Studied

At the pulverized coal session, Walter J. Wohlenberg and Donald G. Morrow, both of Yale University, presented a paper entitled "Radiation in the Pulverized-Fuel Furnace" which is published in abstract on other pages of this issue.

A. G. Christie, professor of mechanical engineering, Johns Hopkins University, presented a paper entitled "Boiler Furnaces for Pulverized Coal" in which he discussed the methods of heat transfer, nature of combustion, furnace walls, coal driers and characteristics of pulverized coal ash.

The conclusions which he draws from the analysis which he made indicate that for the highest efficiency and maximum capacity coal should be thoroughly dry and be finely ground and preheated before admission to the furnace, the air entering the furnace should be highly preheated, turbulence should be maintained in the furnace to insure rapid combustion and high efficiency and furnace walls should be water cooled, preferably with all metal walls.

That the usual method of specifying pulverized coal by its fineness, given as the percentages of the sample passing through standard 100-mesh or 200-mesh screens, is not necessarily indicative of the quality of such coal, was a statement made by L. V. Andrews, of the development department of Riley Stoker Corp., in his paper entitled "A Microscopic Study of Pulverized Coal." He pointed out that there must be a uniform graduation, or rather similar graduation of the sizes of particles from the coarsest to the finest in the samples to be tested if a fair test of pulverizers is to be obtained. In his opinion, the microscope should be consulted, or a more elaborate screen test run than is usually done, in all cases where it is desired to know exactly what quality of pulverized coal is being delivered by the machine.

One of the papers presented at the Milwaukee session was that entitled "Duty Tests of Vertical Triple-Expansion Pumping Engines, Milwaukee, Wis.," by Charles A. Cahill, consulting engineer. In this paper the author states that the choice of engines of the triple-expansion type for installation in the new Riverside Pumping Station at Milwaukee was due to their great reliability, high economy and low cost of maintenance.

At the industrial power session a paper entitled "Torsional Vibrations and Critical Speeds of Shafts" was presented by Arnold Lack and Charles B. Jahnke, both of Fairbanks-Morse and Co. The authors dealt with the subject in an analytical way, reaching the conclusion that the magnitudes of torsional vibration and critical speeds can be calculated, as was done in the paper, for any engine when all necessary data are given.

Another paper presented at this session described a "Test of a Uniflow Engine" by George H. Barrus, consulting steam engineer of Boston. An abstract of this paper appears on other pages of this issue.

Steam Power Session

"Lake Waters for Condensers" was the title of Professor A. G. Christie's paper before the steam power session in which the author pointed out the persistence of stratification of warm and cold water layers in the northern lakes of the country and other deep waters.

The author presented considerable data concerning the temperature of our northern lakes which has been collected and published by biologists in their study of fish life and other organisms and by water supply engineers. He concluded his paper with the statement that temperature-depth studies of the particular lake adjacent to the proposed power house site should be made to furnish exact data upon which a rational decision can be based.

Another paper presented before the steam power session was that entitled "The Rational Design of Covering for Pipes Carrying Steam up to 800 Deg. F." by W. A. Carter and E. T. Cope, both of the research department of the Detroit Edison Company.

In this paper the authors presented an analysis of the problem of determining the most economical thickness of pipe covering for pipes carrying steam of a total temperature of 500 deg. F. and at higher temperatures up to 800 deg. F., based on the work of Heilman, Eberle and others.

Included in the paper were curves showing the method of determining the most economical thickness of covering for a 6-in. pipe carrying steam at 500 and 700 deg. F.

Hans Dahlstrand, mechanical engineer of the Allis-Chalmers Manufacturing Co., contributed a paper entitled "A Review of Steam-Turbine Development." Greater economy and more reliable operation of all prime movers employed in producing energy has been forced by the constant increase in the use of electrical energy for various purposes.

Mr. Dahlstrand's paper dealt chiefly with the effects which the use of steam at higher pressures and temperatures has had upon the efficiencies of steam turbines and upon the materials used in construction of their parts. Careful analysis was made of the use of high back pressure steam turbines to be installed in connection with boilers of high pressure in such a way as to exhaust into the steam mains and turbines of existing plants and the effects on the efficiencies of units of 10,000 to 30,000-kw. capacity were graphically presented.

"Analysis of Power-Plant Performance Based on the Second Law of Thermodynamics" was the subject of a paper presented by William L. DeBaufre, of the University of Nebraska, at the power session. This paper gave details of a step-by-step method of analyzing steam power-plant performance that shows the losses of available energy occurring in each stage of the process.

At the close of his analysis the author presented a second-law balance summing up the losses of available energy in the following items: unavailable due to unburned fuel, etc.; unavailable part of radiant heat; unavailable energy in fire box gases; available energy lost in smoke-box gases; available energy lost in heat transfer; heat transformed into work; available energy lost by the imperfection in cylinders, and available energy lost in exhaust. He believes that while somewhat more complicated calculations are required for the second-law balance than for the first-law balance, the facts revealed thereby will more than justify its extended use.

M. K. Drewry, technical engineer of power plants, Milwaukee Electric Railway and Light Co., contributed a paper entitled "The Comparison of Actual Performance and Theoretical Possibilities of the Lakeside Station." In the preparation of this paper the author used operating and test figures of the Lakeside Station to show the degree of perfection in the design and operation of a high efficiency, straight-Rankine-cycle station, and pointed out the magnitude of each individual heat and availability loss occurring in actual practice.

In his conclusions he made the statement that a modern power station may be so designed and operated that its ultimate efficiency will be within 5 per cent of the combined efficiency of its component equipment working at most economical load. In other words, a 5 per cent allowance can represent all the losses attendant with actual production of power, such as banking of boilers, starting of turbines, uneconomical loading of turbines, etc. The combination of boilers, turbines and auxiliaries, allowing for radiation and miscellaneous losses, may work at an efficiency ratio of 64 per cent in a pulverized-fuel station. This percentage multiplied by the thermal efficiency of the cycle employed and by 95 per cent operating efficiency ratio should give the approximate ultimate overall thermal efficiency of any pulverized-fuel station using the usual equipment.

New Officers Nominated

The nominating committee reported the following ticket to be voted on as officers for 1925-26:

President: William L. Abbott, Chicago, Ill.

Vice-Presidents: Roy V. Wright, New York, N. Y.; A. G. Christie, Baltimore, Md.; William T. Magruder, Columbus, Ohio.

Treasurer: Erik Oberg, New York, N. Y.

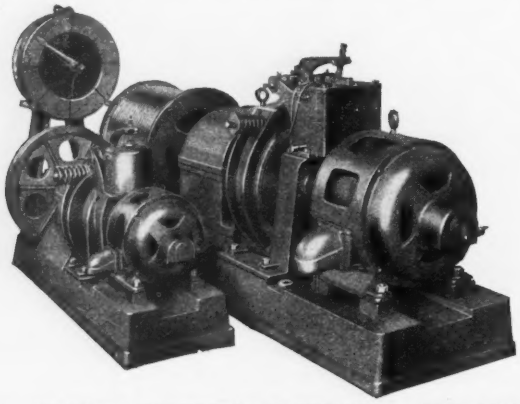
Managers: Charles E. Gorton, New York, N. Y.; William Elmer, Altoona, Pa.; Robert L. Daugherty, Los Angeles, Calif.

Representatives on American Engineering Council: Ira N. Hollis, Worcester, Mass.; Hugh L. Thompson, Waterbury, Conn.; S. H. Libbey, New York, N. Y.; Arthur M. Greene, Princeton, N. J.; Dexter S. Kimball, Ithaca, N. Y.; William B. Powell, Buffalo, N. Y.; John T. Faig, Cincinnati, Ohio; William L. Abbott, Chicago, Ill.; John L. Harrington, Kansas City, Mo.

Spring meeting for 1926 will be held in San Francisco, Calif.

Mono-Rail Cable Conveyor for Coal and Ash

RECENTLY THE Conveyors Corporation of America, Chicago, Ill., placed on the market the American mono-rail cable conveyor, which is applicable to the handling of loose materials, such as coal and ash. The essentials of this equipment are, a hoisting machine, a traction machine and an overhead cable runway, on which is operated materials handling buckets. The hoisting and traction machines are driven by separate motors and are so designed that all gears are enclosed. Clutches are not used. Brakes are of the magnetic type and automatic stops guard against careless operation. The fact that these machines are electrically operated and controlled has eliminated the use of control levers. The traction machine, shown at the left in the cut, is provided with an indicator dial which shows the location of the bucket on the horizontal runway.



DIAL INDICATES HORIZONTAL MOVEMENT OF THE BUCKET

When the bucket reaches the top of its rise, the power is shut off and the magnetic brake on the hoisting machine is set automatically. The traction machine then moves the bucket in the horizontal plane. This machine is automatically controlled and stops when the bucket reaches the end of the cable runway.

Government Surveys Eagle River

POTENTIAL POWER of Eagle River, Colo., below Red Cliff amounts to 28,000 hp. for 50 per cent of the time and 13,500 hp. for 90 per cent of the time, whereas only 325 hp. is now utilized, according to a report prepared in the Department of Interior. The total fall of the river from Red Cliff to its mouth, a distance of 53 mi., is 2440 ft., practically all of which could be utilized in 14 proposed water-power plants. Power could be developed by means of open conduits or pipe lines averaging several miles in length, but the cost of construction should not be high because of the low capacity required. The diversion dams proposed would be inexpensive rock-fill or concrete structures about 4 ft. high.

At one site, a conduit 8 mi. long, having a capacity of 67 sec.-ft., would create a head of 640 ft. and permit the development of 3400 hp. for 50 per cent of the time and 1500 hp. for 90 per cent of the time. At another site a conduit 7 mi. long, having a capacity of 240 sec.-ft., would create a head of 258 ft. and permit the development of 4900 hp. for 50 per cent of the time and 2500 hp. for 90 per cent of the time.

An illustrated manuscript report containing a plan and profile of Eagle River and describing its water-power resources has been prepared for the Department of the Interior by E. E. Jones, hydraulic engineer of the Geological Survey. This report may be consulted at the office of the Geological Survey at Washington, D. C., or at the district office of the Survey at 403 Federal Building, Denver, Colo., and a copy will be sent to any other district office of the Geological Survey on application.

Chain Grate Stokers for Small Units

NATURAL DRAFT, chain grate stokers are now made by the United Stokers Co., La Porte, Ind., in small sizes 3 ft. wide by 7 ft. long up to about 7 ft. wide by 12 ft. long. These are designed as the type "S" stoker to differentiate between them and the larger type made by that company. The new stoker is, in fact, an adaptation of the larger stoker except that the side frames have been discarded because it is designed to be built into the setting.

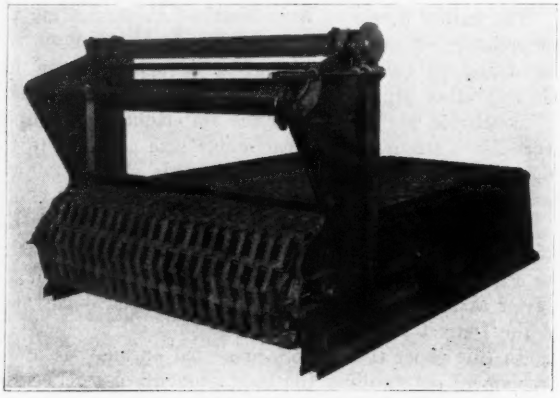


FIG. 1. GRATES DO NOT DISENGAGE, THUS MAINTAINING A TRUE ALINEMENT

The new type of grate surface permits the removal of sections without breaking the continuity of the drive chains. This allows the hole made in the grate surface to be moved back to any part of the stoker and that part inspected and repaired without removal from the furnace.

Grate surface is carried on drive chains supported on rollers running on tracks, as there are no moving parts at the rear of the stoker, hence no rear shaft. The rollers run around castings at the rear of the stoker and are fed onto the lower tracks so that every moving part of the grate comes forward periodically where it can be reached easily.

Grate surface construction and the fuel gate construction are exactly the same as in the larger stoker. Any grate can be removed without disturbing any other and this can be done without stopping the stoker. Only one pattern of grate is used for the entire grate and this same pattern is used for the spare.

The fuel gate is made of cast iron and tile. Each tile is supported on a tapered cast-iron pin throughout

its full length. With this means of support it is impossible for a tile to became cracked in such a way that it will be displaced. The ends of the supporting pins can even be burned off piece by piece without impairing their support. It is not necessary to take the stoker out of service in order to replace tiles, since they, with their cast-iron shoes, are individually hung and can be replaced from the stoker hopper.

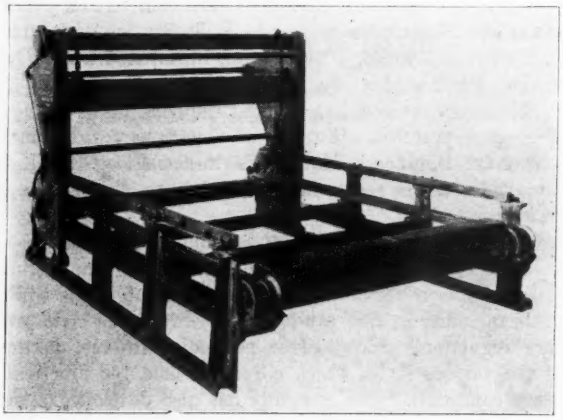


FIG. 2. SIDE FRAMES HAVE BEEN ELIMINATED AND THERE ARE NO MOVING PARTS AT THE REAR OF THE STOKER

This stoker is designed so that the grate surface is only 24 in. above the floor line. Thus it is claimed that an acceptable setting with a flat arch can be made under a horizontal return tubular boiler set 5 ft. from the floor.

All Roads Lead to San Francisco for June

AT THE coming meeting of the National Electric Light Assns. in San Francisco, June 15-18, business and pleasure will be suitably combined. Monday will be devoted largely to registration and arrangements for the later sessions, with the formal annual President's Reception and Ball in the evening at the Fairmont Hotel.

Four general sessions will be held in the main auditorium of the convention building on the mornings of Tuesday, Wednesday, Thursday and Friday from 9:30 to 12:30. National sections on Public Relations, Commercial Features and Technical Features will each hold three sessions on Tuesday, Wednesday and Thursday afternoons and the Accounting section will hold two sessions on Tuesday and Wednesday afternoons, all beginning at 2:30.

Wednesday evening a public policy meeting will be held in the main auditorium, at which it is expected that Hon. Herbert Hoover will be the principal speaker.

At times when sessions are not being held, visitors will find available, golf, tennis, dancing, concerts, excursions and especially for the ladies teas and card parties. Friday afternoon and Saturday will be especially devoted to golf, 16 courses being available. On Friday afternoon, a trip by electric boats will give opportunity to see the Bay, Golden Gate and the industrial development of the city.

After the convention longer trips to inspect hydroelectric properties are planned and shorter ones to see the progress of rural electrification.

Milan R. Bump Dies

MILAN RAYNARD BUMP, chief engineer for Henry L. Doherty & Co., New York, and former president of the N. E. L. A., died on May 5, at Denver, Colo., following an illness of two days caused by hemorrhage of the nose and heart trouble.

Mr. Bump was born on March 18, 1881, at Rock Falls, Wis. He spent his boyhood in Spokane, Wash., where he attended the public schools. After graduation from the University of Wisconsin in 1902 with a degree of B. S. in electrical engineering, he went to the Washington Water Power Co., but in 1903, returned to Madison, where he served as an instructor in electrical engineering at the University of Wisconsin. In 1904, Mr. Bump entered the employ of Henry L. Doherty & Co., and from that time until 1910, served successively as engineer of the Denver Gas & Electric Light Co., examining engineer for Henry L. Doherty & Co., and treasurer and general manager of the Empire District Electric Co.

In 1910 Mr. Bump was sent to New York as chief engineer of all the Doherty interests; he also had charge of oil transportation, refining and marketing divisions and the natural-gas division. In 1915 he became vice-president of the Eagle-Picher Lead Co., in Joplin, Mo., but soon returned to the Doherty organization. He was always active in public utility affairs, serving on many committees of the N. E. L. A. and other engineering societies. He was elected president of the N. E. L. A. in 1921, after 4 yr. service as vice-president.

News Notes

D. H. SKEEN & Co. are now in their new quarters, 1362 Monadnock Block, Chicago.

H. P. RODGERS has recently been appointed by the Conveyors Corporation of America to handle the American Mono-Rail Cable Conveyor in the state of Ohio. His office is in the Leader Building, Cleveland, Ohio.

UNION IRON WORKS has recently moved its New York office from 50 Church St. to 122 Greenwich St. This office is in charge of Joseph Lappin and the new quarters provide larger offices and better facilities for service to the New York territory.

LINK-BELT CO. has just announced that it has placed in operation a new plan by which complete lines of silent chain drives of from ¼ to 10 hp., in practically any reduction from one to one to seven to one, are now available for immediate delivery, by distributors located in many principal cities of this country. For more than 20 yr. the installation of silent chain drives has been an engineering problem. Under the Link-Belt plan it remains somewhat of an engineering problem, but one which has been simplified in conveniently arranged tables, which have been published in book form for distribution by this company.

L. W. HELLER, who has for a number of years been General Superintendent of Power Stations of the Duquesne Light Company, Pittsburgh, Pa., has recently resigned from this position to become General Engineer for the Bailey Meter Company, Cleveland, Ohio.

A. O. BACKERT, for many years editor of Foundry and Iron Trade Review and, since 1924, President and General Manager of Penton Publishing Co. of Cleveland, died from heart disease on April 24 at his home in Lakewood,

O. Mr. Backert has been one of the foremost advocates of progress in the iron and publishing industries, a writer of authority, an executive of great ability, a friend of sterling worth. His going is a severe loss to all who knew him.

MAJOR WILLIAM HALSTED WILEY, of the publishing firm of John Wiley & Sons, Inc., treasurer of the A. S. M. E., and former U. S. Congressman, died on May 2 at his home in East Orange, N. J., at the age of eighty-two years. Major Wiley was born in New York. In 1861 he graduated from the College of the City of New York. During the Civil War, he rose to the command of two companies of artillery and upon his retirement was brevetted major for gallant service. In 1866 he resumed his studies, receiving an engineer's degree from Rensellaer Polytechnic Institute and taking a year of special work at the Columbia School of Mines. His business career began in 1876 with John Wiley & Sons, Inc., publishers of scientific books. From 1903 to 1907 and from 1909 to 1911 he represented the Eighth New Jersey District in Congress.

COL. WILLIAM KELLY, who for the past 5 yr. has been chief engineer for the Federal Power Commission, has recently resigned that position to become director of the department of engineering of the National Electric Light Association. He will be stationed at the association headquarters in New York City and will have direction of all engineering activities of the association's engineering staff. Questions of inter-connection, power surveys, inductive interference and co-ordination, as well as the general questions of generation, transmission and distribution, are constantly presented to the N. E. L. A. engineering department through committees of the Technical National Section or directly by companies interested. Colonel Kelly will keep in personal touch with the major problems and developments along these lines and will direct the engineering staff in its contact with member companies, communication companies and other public utilities.

THE NINETEENTH ANNUAL convention of the Smoke Prevention Association will be held June 17 to 20, 1925, at the Hotel Pantlind, Grand Rapids, Michigan. H. B. Meller, president of the association and chief of the bureau of smoke regulation, Pittsburgh, Pa., announces that the program will include papers by a number of recognized authorities on the subject of smoke abatement. Among the papers will be one on the use of oil burning devices as an aid toward the elimination and abatement of smoke. As is the custom of the association, one day of the convention will be devoted to the railroad men, on which day John B. Irwin, vice president of the association, and chief smoke inspector of the C. & N. W. R. R. will preside.

VULCAN IRON WORKS, San Francisco, are now installing at Salinas, Calif., for the Salinas Beverage & Ice Co., a 30-T. vertical single action Vulcan ammonia compressor, direct connected to motor drive. Circulating water will be handled by a Van 2-stage centrifugal pump. A Best water softener is also included. L. G. Flint of the Vulcan Iron Works is superintending construction and when completed H. J. Terry will be chief engineer.

CYRUS WM. RICE & Co., water chemists and engineers of Pittsburgh, Pa., announce the opening of an office in New York City at 48 East 41st St. The office is in charge of D. C. Carmichael.

T. A. WORK LUMBER Co., Monterey, Calif., are about to install a new boiler and engine plant, having outgrown the one they are now using.

HOTEL DEL MONTE, Del Monte, Calif., are now installing a 200-kw. G. E. steam turbine, to generate their own power. B. C. Johnson is chief engineer.

Books and Catalogs

ROPER'S QUESTIONS AND ANSWERS FOR STEAM ENGINEERS and Electricians revised by R. T. Strohm and James D. Purdy, 352 pages, 4 by 5¾ in., imitation leather; 7th edition, Philadelphia, Pa.; price, $2.00 net.

Thorough revision has brought the book up to methods of modern practise. It treats of Questions for Firemen, Stationary Engineers, Marine Engineers, Electrical Questions, and a short catechism on what to do in case of accidents.

MASON REGULATOR Co., of Boston, Mass., has just issued its General Catalog No. 62, describing the various types of Mason regulating appliances. Among the equipment included in this catalog are a number of new pressure regulators which are of particular interest because of the various styles which cover the field for practically every condition. The company has also developed a new line of small regulators for air and water, details all of which are included in the catalog.

THE GRISCOM-RUSSELL Co., New York City, has just issued a leaflet describing the Reilly evaporator set which is designed especially for furnishing small quantities of distilled water. This set forms a complete plant consisting of evaporator, distiller, aerating filter, automatic feeder and all the necessary interconnecting piping, fittings, valves and traps, all mounted on a single angle iron frame. The rating of the unit is 30 gal. per hr.

ENGBERG'S ELECTRIC and Mechanical Works, St. Joseph, Mich., have just issued Catalog No. 105, which describes Engberg direct current connected generating sets.

BULLETIN No. 808 just issued by the Fulton Iron Works Co., of St. Louis, Mo., describes in considerable detail the type J Fulton Diesel engine. In addition to listing the engine sizes the catalog also includes a diagram of the engine and a tabulation of the principal dimensions for the several sizes.

ARCOFRAX BRICK is the subject of a special survey report, made by the A. C. Nielson Co. for the General Refractories Co., of Philadelphia. This report shows that the use of Arcofrax brick in cement kilns in a certain plant resulted in a saving of $3375 per year on three kilns.

STANDARD BULLETIN, VOLUME III, on the subject of Turbine-driven Underwriters' Fire Pumps has just been published by the Standard Turbine Corporation of Scio, New York.

BULLETIN No. 42,567 has been issued by the General Electric Co., describing its sine wave generator. The bulletin is in the form of a four-page leaflet containing, besides the text, photographs, charts, diagrams and tables. The different testing applications of this generator are explained.

BULLETIN No. 112 just issued by the Hill Clutch Machine and Foundry Co., Cleveland, Ohio, describes the Cleveland type collar oiling bearing which has a positive oil feed and distributing system. These bearings are obtainable in all styles of rigid, ball and socket mountings, adjustable four way.